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THE U. S. STEAMER ALBATROSS.

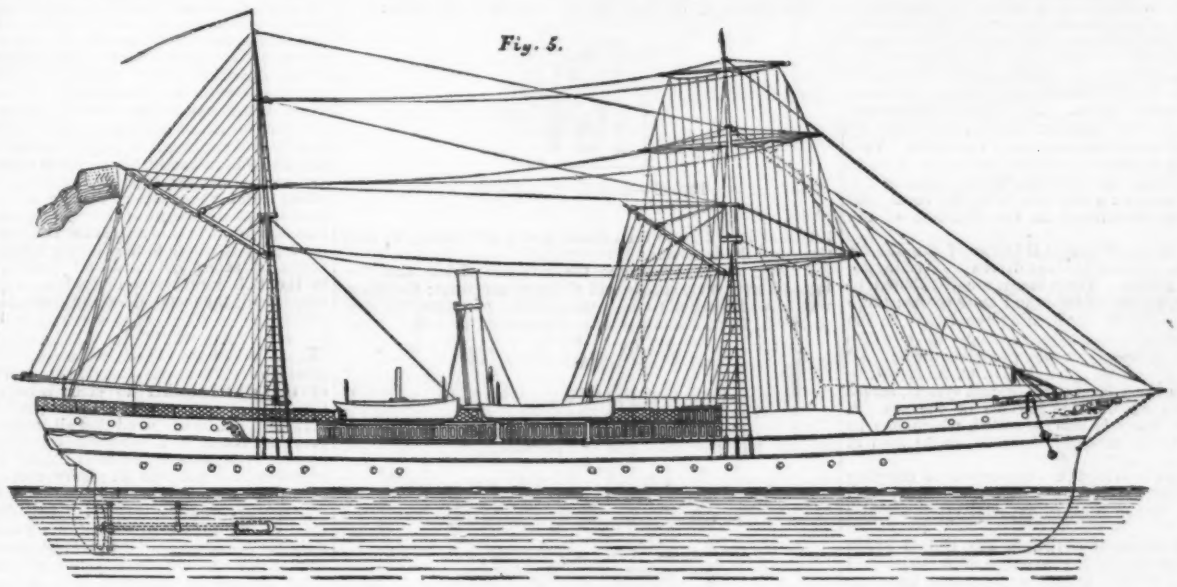
In our present number we are enabled, through the kindness of Mr. G. Brown Goode, the chief of the United States Commission at the Fisheries Exhibition, to lay before our readers illustrations of the Albatross, a vessel lately built by the Pusey & Jones Company, of Wilmington, Delaware, to the order of the United States Fish Commission. She was designed by Mr. Charles W. Copeland, consulting engineer to the United States Lighthouse Board, while Lieutenant Commander Z. L. Tanner, U. S Navy, who will have the first command, has supervised the building and fitting the vessel for her special mission. The launch was successfully made on August 19, last year. The vessel is designed expressly for the purpose of deep sea exploration, and is fitted with a very complete set of scientific apparatus of the most approved types. For the present we shall content ourselves with giving such details of the vessel as may be necessary to explain our illustrations, hoping to return to the subject at a future date.

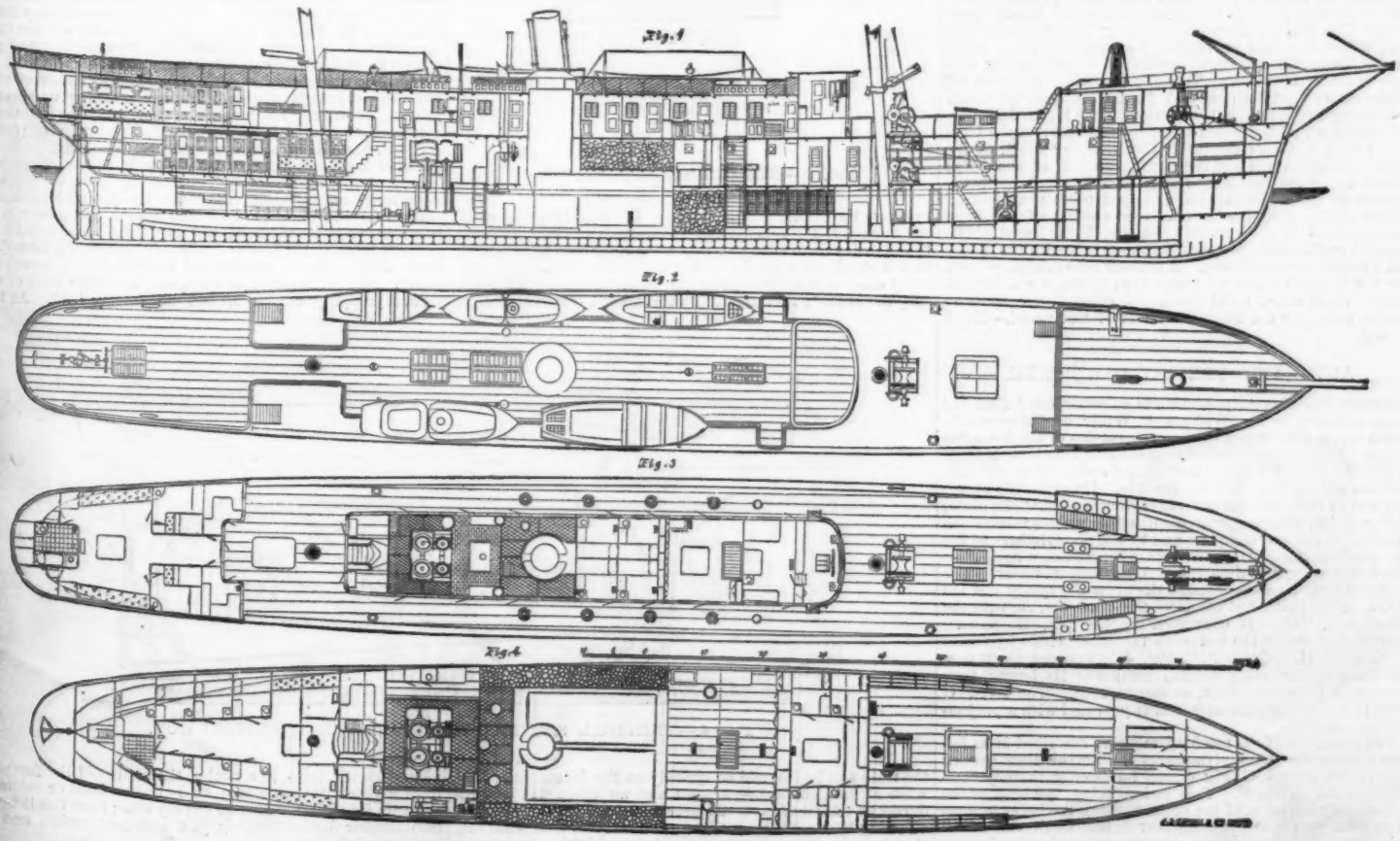
For most of the particulars now quoted we are indebted to the forthcoming issue of the United States Fish Commissioner's Report, the advance sheets of which have been kindly placed in our hands by Mr. G. Brown Goode.

The hull is modeled to go astern with facility, a maneuver which often requires to be executed when sounding or dredging to great depths in a seaway. The rudder and its attachments are of extra strength, and in addition to the hand and steam steering gear in the pilot house, there is a powerful screw gear attached directly to the rudder head, a heavy iron tiller on the poop-deck for relieving tackles, and the usual rudder chains. As is shown by our illustration, the Albatross has two masts and carries a square fore topsail and fore top-gallant sail. Her principal dimensions are: Length over all, 234 ft.; length at 12 ft. water line, 200 ft.; breadth of beam moulded, 27 ft. 6 in.; depth from top of floors to top of deck beams, 16 ft. 9 in.; displacement on 12 ft. draught, 1,000 tons. There are five transverse iron bulkheads, and six water-tight compartments. Of the structures which rise above the main rail, the poop cabin extends 30 ft. forward of the stern-post; it occupies the whole width of the vessel, and is 7 ft. 3 in. in height from deck to deck. It contains two state rooms, bath room, pantry, etc. The deck-house is 83 feet in length, 13 ft. 6 in. wide, and 7 ft. 3 in. high from deck to deck. From the funnel aft it is built of iron and sheathed with wood inside and out, and is fitted with iron storm doors, but from the funnel forward it is of wood. Beginning aft in the iron house, the following is the arrangement of the space: 1. Entrance to wardroom stairway. 2. Upper engine room. 3. Galley. 4. Steam drum room. In the wooden part; 1. Four staterooms for civilian scientific staff. 2. Upper laboratory, 14 ft. in length, and the whole width of the house. This room contains a central work-table, three hinged side tables, a sink with alcohol and water tanks attached, wall cases for books and apparatus, and the medical dispensary. 3. Chart room, the width of the house and 8 ft. 6 in. in length. 4. Pilot house, 8 ft. in length, the whole width of the deck house, with elliptical front and glass windows protected by strong wooden shutters. The pilot house projects 3 ft. above the deck house.

The top-gallant forecastle is 44 ft. in length and 6 ft. 3 in. in height from deck to deck. The anchors, which are stowed on this deck, are handled by a single fish davit and a steam capstan. On the port side near the after end is the Sigsbee deep-sea sounding machine. Under the top-gallant forecastle are water closets for officers and crew, men's bath room, lamp room, paint locker, steam windlass, etc. There are two scuttles under this deck, one giving access to store rooms, magazines, etc., forward of the collision bulkhead; the other, leading to the berth deck, is for use in bad weather. The fore-hatch also gives access to the berth deck, which extends 40 ft. fore and aft, is 7 ft. 10 in. in height between decks, and is comfortably fitted for the accommodation of the crew. Opening from the after end is the steerage, provided with four double berth staterooms and

Fig. 5.





THE UNITED STATES FISH COMMISSION STEAMER ALBATROSS.

a mess room. Abaft the steerage, but separated from it by an iron bulkhead, is the lower laboratory immediately below the upper laboratory, through which it can be entered. This room extends quite across the ship, is 20 ft. long, and 7 ft. 10 in. in height between decks. Ample storage cases and lockers are provided for alcohol jars and specimens; long work-tables are placed on each side; in one corner is a large lead-lined sink with running water; and in another a photographic dark room. Across the after end is the chemical laboratory. Below this is the store room, which is a closed iron box capable of being isolated from the rest of the ship and filled with steam at short notice in case of fire. Here are stowed alcohol, specimens, nets, etc., for which lockers have been provided.

The vessel is propelled by twin screws 9 ft. in diameter and 14 ft. 10 in. mean pitch. They are driven by a double pair of compound condensing engines with cylinders 18 in. and 34 in. in diameter, and 30 in. stroke of piston. The condenser is common to both engines and forms their framing. The upper ends of the cylinders are drawn inboard over the condenser, making the engines slightly inclined. The condenser contains 2,150 square feet of cooling surface. There are two horizontal air pumps, an independent circulating pump, two main feed pumps, and two auxiliary pumps, which can be used either as feed pumps, for fire purposes, or as bilge pumps. There are two overhead return flue boilers 8½ ft. in diameter, 21½ ft. long, with 93 square feet of grate surface, a "steam chimney" or superheater 7 ft. 4 in. in diameter outside and 14 ft. high above the shell.

The wardroom next aft of the engine department has eight staterooms with bath room and pantry. The navigator's and paymaster's rooms, wardroom, and store rooms are in the hold below these quarters. In the forehold are the water tanks, bread room, sail room, engineer's store rooms, cold room, and ice house. Forward of the collision bulkhead are the boatswain's and dredging store rooms, the magazine, etc. The special engines of the ship are as follows, viz.: A Providence steam windlass and capstan, built by the American Ship Windlass Company of Providence, R. I.; a hoisting engine for dredging on the spar deck forward of the foremasts; and a reeling engine on the berth deck below is used for reeling up the dredge rope. Both the latter were made by Copeland & Bacon, of New York. Higginson & Co.'s steam quartermaster, by the Pusey & Jones Company, is placed in the pilot house. Wise's steam motor drives a Sturtevant exhaust fan for ventilating the ship; an ash hoister, designed by Passed Assistant Engineer G. W. Baird, U. S. Navy. Svedberg's marine governors are attached to the main engines. An Edison dynamo and engine are used for electric lighting. Heat is provided by steam radiators in all inhabited quarters of the vessel. Ventilation is secured by means of conduits leading to all parts of the ship through which air is drawn by the exhaust fan above mentioned, placed on a platform in the fire room, and arranged to discharge downward in the direction of the furnaces.

Light is supplied by 1,208 candle B lamps of the Edison incandescent system, and a Z dynamo driven by Armington & Sims' high-speed engine. These lamps are distributed in all parts of the ship, including holds and store rooms; there are also twelve lamps outside for lighting the deck. In the laboratories the lamps are especially numerous and are pronounced to be quite sufficient for any probable needs. An arc lamp of great power, designed by Dr. O. A. Moses, to work in circuit with the Edison incandescent system, serves for illuminating the surrounding surface of the sea. A powerful submarine lamp is also provided, which can be lowered to any depth not exceeding 1,000 ft., to be used in deep-sea explorations.

Two steamboats are provided for the purpose of carrying on the work of scientific research. They are fitted with Herreshoff boilers. Other boats of especial types are also carried.

A model of the Albatross is shown in the United States Court at the Fisheries Exhibition, together with models and full sized examples of the scientific apparatus and gear necessary for the work the vessel is designed to accomplish. Among these appliances the following may be briefly mentioned: The Sigsbee deep-sea sounding machine, sounding rods, water cups, and gravitating trap for collecting specimens at known intermediate depths; it is built by D. Ballany, Washington, D. C. Tanner's sounding machine for depths under 1,000 fathoms and for navigational purposes. The dredging boom, 36 ft. in length by 10 in. in diameter, the heel of which is pivoted to the forward part of the foremast 7 ft. 2 in. above the deck; the dredging block at the boom end, the sheave and register at the heel of the boom for indicating the length of dredge rope out; and the accumulator at the foremast head arranged to prevent jerking strains on the rope (the accumulator used is of the form recommended by Commander Sigsbee, U. S Navy). The Negretti and Zambra deep-sea thermometers with the Bailie and Tanner improved cases. A Chester rake dredge, a beam trawl, a deep-sea trawl, a Chester towing net, together with tangles, table sieve, trawl lines, and other minor appurtenances, complete the scientific outfit of the vessel.—*Engineering.*

AUTOMATIC FREIGHT CAR BRAKE.

Among recent inventions is that of an automatic freight car brake, patented by Mr. William A. Wilde, of Chicago, Ill., which obtains its power by the compression of the draw bar spring. This spring is inclosed in the cast iron box, E (Fig. 1), which is provided with a hole in the center of the forward end and with a long slot in the side. On each side of the rear end of the draw bar is a wedge, shown at K. The plate, D (Fig. 2), has a vertical movement within guides fastened to the sides of the cast iron box and to the floor timbers of the car, and is perforated by the rectangular slots, *o n*, near its lower extremity, and with the slot, *m*, near its upper. The draw bar bolt, *c*, passes through the draw bar spring and the slot, *o*, in the plate, and connects the draw bar, A, with the follower, *q*, which is connected by the pin, G, passing through the slot in the box with the brake chain by means of the lever, H. The bolt, C, Fig. 4, is reduced about one-half its diameter along a small portion of its length, thus forming a recess or neck, as shown at X. The lever, O (Fig. 1), has its fulcrum at *g*, and is provided with a projecting branch, *f*.

The operation of the mechanism above described is as follows: When the locomotive moves it pulls the draw bar out and with it the rod, C (Fig. 4), and follower, *g*, thereby compressing the spring, F. This action brings the neck of the rod within the slot, *o*, of the plate, causing the latter to drop of its own weight to find a support in the small end of the slot, thus holding the spring compressed and releasing the brakes, owing to the loosening of the chain, *l* (Fig. 1), by the forward movement of the pin, G. To put on the brakes it is simply necessary for the engineer to put the brake on the locomotive, when the draw bar will be forced in, causing the wedges, K, to enter the slots, *n*, by which the plate is raised and the spring released and the brakes set.

In backing, the reverse bar, A B (Fig. 3), is forced in and

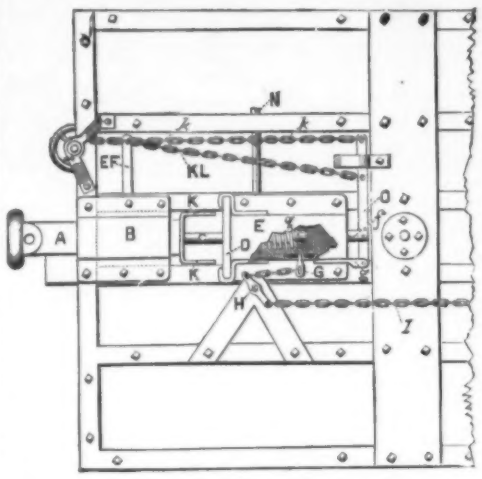


Fig. 1.—PLAN SHOWING BOTTOM OF CAR INVERTED.

carries with it the bifurcated lever, E F, which in turn draws the chain, K L, forward and with it the lever, O (Fig. 1), which forces forward, the follower, *q*, thus loosening the brakes. For use around yards there is provided a device which, by winding up the regular hand brake, first

Fig. 2.—LOCK PLATE D.

lifts the plate, D, and then draws forward the lever, O, thus throwing the brake off.

Among other advantages the inventor claims that the brake is extremely simple and cheap to construct; that there will be no flat wheels and consequently no returning; that there will be no strain upon the locomotive, as a slight pressure sets the brakes on the first car and they in turn set all the rest; foreign cars do not interfere with its operation; that it will take up its own slack as the shoes wear away; that it steadies the motion of the train; that it will stop runaway cars, as they cannot go far without touching and setting the brakes; that as all brakes are set instantaneously, the train can be stopped as quickly as the locomotive; that when at rest all brakes are set and no effect will be produced by the wind; the engineer can regulate the speed of stopping by drawing ahead as soon as the brakes are set, thereby releasing as many of the forward brakes as he may desire.

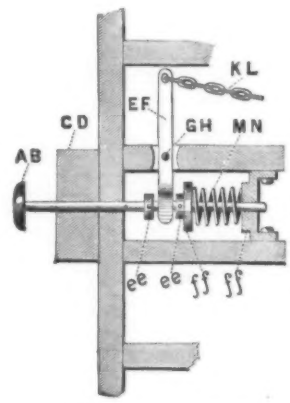


Fig. 3.—REVERSING APPARATUS

THE GENESIS OF A CAR WHEEL.

It is estimated that there are ten million car wheels whirling over this country at the present moment, conveying millions of passengers and more millions of tons of freight to and fro across the continent at an average speed of 25 miles an hour for passengers, and often forty miles. How many of the hurrying multitude who trust their lives on the rail pause to consider the admirable mechanism by which these great results are accomplished? How many complex problems have been solved in the gradual evolution of the old-time stage coach into the modern iron horse and his train?

Take, for example, a car wheel, one of the simplest parts of a railway train; it is merely a round piece of iron, and as we generally see it covered with dirt and grease, having nothing attractive or ornamental in its appearance, and seemingly gross in its construction; yet that smaller and more valuable disk, known as "Uncle Sam's" double-eagle, which issues from the Mint glittering like a mirror, does not involve in its manufacture more intricate, and, in some respects, more delicate manipulation than this same gross car wheel.

The most important difference between a car wheel and any ordinary machine or apparatus made of cast iron, is the fact that the tread of the wheel, viz., that part which runs on the rail, is quite different in character from the plate or main body, though cast from the same metal in one pouring. The tread or rim is actually harder than the finest steel, thus enabling it to resist not only the wear upon the steel rail, but the still more destructive grip of the brakes, and its average life is not far from 100,000 miles of service.

The process by which the hardening of the tread is produced is called chilling, and is somewhat analogous to the tempering of steel. A mould is made in sand from a wooden pattern, the moist sand is pressed by the moulder against both sides of the pattern with a hand rammer, and it is then sufficiently tenacious to enable the pattern to be carefully removed without destroying the mould; this "sand mould" is inclosed in a ring made of iron called the "chill mould," whose internal face has been previously turned upon a lathe to form the tread and flange of the wheel; numerous air passages or vents are made through the sand with a long needle to permit the gentle escape of highly explosive gases, which are formed when the molten iron is running into the mould; the stream of glowing fluid iron quickly fills the hollow space between the upper and lower sides of the sand mould, and running to the edge comes in contact with the iron ring or chill mould; this being a much better conductor of heat than the sand mould, chills the rim of the casting, not only congealing the iron instantly, but causing it to crystallize (to a depth of about half an inch) in beautiful parallel filaments, as white as silver and nearly as hard as diamond. The portion of the wheel forming the plate or sides cools more slowly, is not chilled, and its texture is the same as that of ordinary cast iron. If the wheel is made of a mixture of iron which is too highly sensitive to the chilling influence, it will be too brittle for safety and too *hard* to permit of boring the hole in the hub into which the axle is to be fitted. If, on the other hand, the metal does not possess sufficient chilling property, the tread of the wheel is too soft and soon becomes flattened by its incessant pounding upon the rail, and then the wheel is useless. The margin between these two extremes is very small, and it is the daily aim of the wheel maker to steer between this Scylla and Charybdis.

It must not be supposed that all irons possess this chilling property, for it is a comparatively rare one, and little is known, even among the most expert iron masters, of the causes which produce it. Very recently some light has been thrown upon this subject by the aid of chemical analysis, and scientific investigation will doubtless reveal still more clearly what is as yet but dimly seen. Pig iron is not a simple substance, but is in reality an alloy composed of at least half a dozen different elements, each one of which helps to stamp its character upon the metal. It has been found, for example, that the substance silicon, which is always present in pig iron, exerts an extraordinary influence upon its chilling power, and a variation of less than one per cent. of silicon is sufficient to make or mar a car wheel; indeed, it has happened that an entire day's work of several hundred men has been spoiled by an excess of one-half of one per cent. of this substance creeping undetected into the mixture. The method of analyzing the iron to ascertain the proportion of carbon, phosphorus, manganese, sulphur, and silicon which it contains is too complicated to admit of a general description; suffice it to say, that a few grains of a sample are reduced to fine powder, weighed upon an extremely sensitive balance, treated with acids and other reagents, or tests, by which means each element is separated from its partners, and its weight ascertained. In a wheel foundry the iron is commonly melted in a large furnace called a cupola, capable of melting fifty or more tons a day. Anthracite coal is used, and a strong blast of air from a pumping engine creates an intense heat. As the

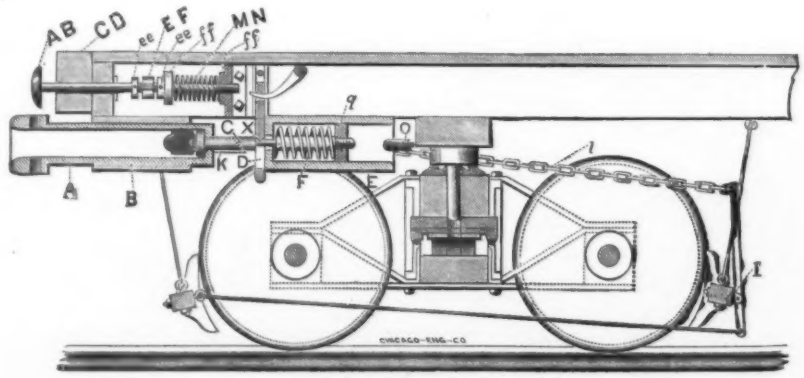


Fig. 4.—VERTICAL SECTION WITH DRAW BAR PULLED OUT.

iron melts it collects in a pool at the bottom of the furnace, from which it is drawn into an immense ladle or caldron, sometimes holding fifteen or twenty tons; from this it flows into smaller ladles holding just sufficient molten iron to make one large wheel.

Great skill is required in pouring the iron into the mould—

it must be just the right temperature and it must be allowed to run into the mould with just the right force; otherwise a bad casting is the inevitable result. After the wheels are taken out from the molds, they require to be thoroughly annealed, as they are subjected to an immense strain due to the more rapid cooling of the chilled tread. For this purpose they are either put into pits previously heated or buried in hot sand, where they are allowed to remain for several days. In this way the molecules (or smallest particles) of the metal gradually arrange themselves in new positions and the strain is entirely removed. The sand which adheres to the wheel is then brushed off, and the wheel tested for strength by heavy blows with a sledge-hammer, and for hardness on the tread by chipping with a highly tempered cold-chisel; in this way any soft spots may be readily detected and the wheel accordingly condemned. There are, in fact, no less than 27 distinct diseases, so to speak, which a car wheel is liable to contract in the course of its manufacture, and it must pass a rigid inspection in the quarantine or cleaning shop before it receives the required guarantee of its maker that it is free from all defects.

Finally, having obtained a clean bill of health from the inspector, the wheel passes to the machine shop, where the hub is bored out, the axle fitted in by hydraulic pressure (of 15 or 20 tons), and the wheel and its mate are ready to start out on their long journey. If they are well matched, they should roll along through their whole life without jarring, and, barring accidents, will often travel 150,000 miles before becoming completely tired out.

The chilled cast iron car wheel is a purely American invention, and the method of annealing, which alone made this process practicable, (?) was devised by a manufacturer in this city as long ago as 1847, since which time between one and two million wheels have been made in the works established by him, and have been shipped to all parts of the world where the shriek of the locomotive whistle has penetrated.—*Philadelphia Ledger.*

COMBINED STEAM ENGINE AND FIRE PUMP.

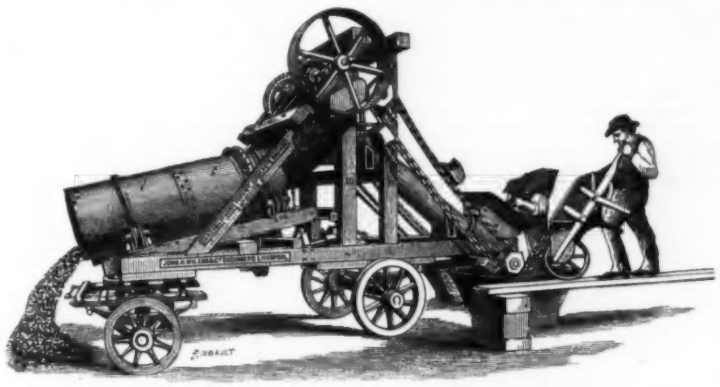
WE give two illustrations of this engine by Shand, Mason & Co., London, one being a side elevation showing the general arrangement, and the other an elevation showing the automatic cut-off gear. The engine is of the return connecting-rod description, with two piston-rods attached to the cross-head, the latter being fitted with adjustable slipper blocks with large bearing surfaces. The connecting-rod is jointed to the center of this crosshead, and a screwed projection is formed for the purpose of connecting the outer end of the pump piston-rod by means of a nut, when the engine is to be used as a fire pump. It will be seen from the engraving that the bed-plate is of great strength, while the steam cylinder is overhung at one end and the fire pump at the other.

The general arrangement of the valve gear is of novel design, the cut-off is automatic, and directly under the control of a governor of the Hartnell type, with several improvements. The main valve is of the ordinary description, driven by an eccentric, with the cut-off valve working on the back and at right angles to its line of motion. The cut-off valve has several narrow ports through it corresponding with similar ports on the back of the main valve, the stroke being short and the frictional resistance correspondingly decreased. The cut-off valve rod is connected at the upper end by links to one end of a rocking lever, to the other end of which is coupled the rod of cut-off eccentric, this latter having a pin forged on it with a bearing in the governor drum; the eccentric vibrates on this pin to the position for early and late cut-off. This pin has a lever keyed on its outer end, as shown, and to this lever is attached a rod from an eccentric forged on a pin, on which is keyed one of the arms of the governor, this arm being connected by a link on which is the governor spring. This arrangement gives the governor complete control over the cut-off eccentric, while the latter has no power to affect the position of the governor arms. With the engine running at 250 revolutions per minute the extreme variation of speed was under twelve revolutions, although in the experiment the cut-off was varied in its full range from one twenty-fifth to five-eighths of the stroke. Self-acting lubricators are fitted to all working parts, the surfaces at the same time being made extra large, with the revolving parts balanced.

CONCRETE MIXING MACHINE.

THE use of concrete in dock and harbor works has now become almost universal, and its employment in these respects frequently involves its application in exceptionally large masses. To insure good results its preparation must necessarily be carried on with rapidity and also with accuracy as regards the proportions of the ingredients. To effect this, mechanical aid has been invoked, and a very effective machine has been devised, which is now doing good service on some of the largest public works in England. One of the best examples which has come under our personal notice is that of the extensive works now being carried out at Newhaven Harbor in connection with the London, Brighton, and South Coast Railway, and which works we not long since inspected.

They are attracting considerable attention in consequence of the extensive use of concrete *en masse*, both in the foundation and superstructure of the breakwater. The bags of concrete sunk from a hopper barge for the foundation weigh each 104 tons, and it may be rather startling to state that the materials ballast, sand, and cement—being brought forward in sufficient quantity, each bag is filled in twenty minutes. Were it not so, the mass would have begun to set before it could be conveyed to its destination and sunk. In the case of the superstructure also it is practicable by the means there employed to bring up the full section of the breakwater from low water mark to the top for a length of from 10 to 15 feet forward faster than the tide will rise.



CONCRETE MIXING MACHINE.

It must be obvious that hand-made concrete could not economically or in reasonable time supply the requirements of these works, but these have been most successfully met by the special machinery designed by Messrs. Carey & Latham, of 10 Halton Buildings, Chapel Street, Liverpool, and erected by the Newhaven Harbor Company, at a very considerable outlay, which is, however, justified by the fact that the machine made concrete is found to cost barely 7d. per yard for labor, while hand-made concrete costs nearly 13d. Moreover, while thirty seven men with the machine put in 240 yards per day, it requires sixty-five men to put in the same quantity by hand only.

The large, powerful machines in use at Newhaven are of course only applicable to public works of similar magnitude, but the great economy and the proved advantages of these machines have induced the inventors to produce a small portable machine which we illustrate on this page, and which was recently exhibited at the Royal Agricultural Show at York, as mentioned by us at the time. It is intended to be available for all kinds of general builders and contractors' works.

The machine is really only a combination of well-known simple mechanical details arranged not only to mix the concrete, but to measure mechanically the materials of which it is to be composed in any quantities determined by the engineer or architect. The mixing cylinder is the ordinary well known arrangement of an inclined cylinder, with blades on its internal surface, in passing through which as it revolves the materials are turned over and over together so as to become effectually mixed, and the water is introduced to the cylinder at such part of its length as may be found to allow of sufficient dry mixing before the wet mixing commences.

The cylinder is fed by two elevators on the dredger principle, one raising ballast and the other sand in the proportion of from 5 to 6 of ballast to 3 of sand, which is, however, variable according to the average size of ballast. These elevators or dredgers take the material out of hoppers, and it is only important that the barrow service should be sufficient to keep these hoppers always filled. The measuring depends simply on the size and speed of the buckets.

Between the two elevators an archimedean screw, working in a tube the bottom end of which is below a hopper, which is always kept full of cement, causes a steady and regular supply of cement in proper proportion to the quantity of ballast and sand raised to enter the upper end of the mixing cylinder. This regular feed of cement, by avoiding patches and lumps, is probably the chief cause of the even texture of the concrete produced by these machines.

The whole arrangement is fixed on a wagon, and weighs altogether about 3 tons, and can be taken along any ordinary road. It can be driven by a 4 or 6 horse-power portable engine, and will produce from 12 to 20 yards of concrete per hour. At the York Show a Buckett caloric engine was used to drive it, which would have some advantage in street and town work, in consequence of the absence of smoke and steam. From what we know of these machines, we do not think them expensive, considering the economy that results from their use; and as they secure the intended quality of concrete, they commend themselves to the attention both of engineers and architects and of their contractors.—*Iron.*

IMPROVED MECHANISM FOR GUNS AND EMBRASURES.

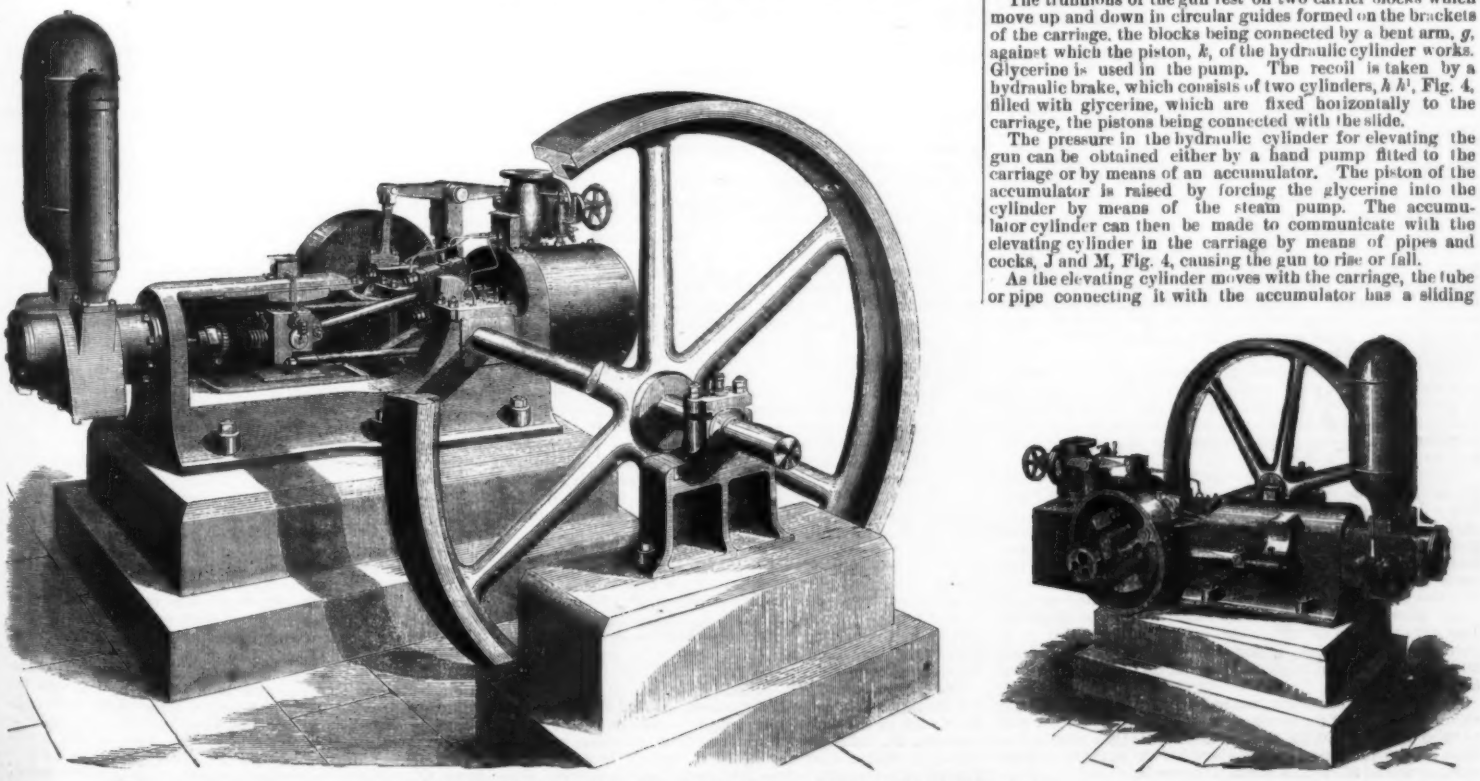
THE defensive qualities of Mr. Gruson's turrets have been greatly increased by the diminished size of the embrasure or port in the armor, consequent upon the introduction of a new description of gun-carriage. The new form of embrasure now affords a high degree of protection against the ingress of shot, being practically closed except for a few seconds after the gun is fired and during its automatic return into battery. This interval during recent trials with a 6-inch gun was found to be four to five seconds.

It is of the nature of carriages known as "port pivoting," the imaginary pivot round which the gun rotates being situated toward the front part of the embrasure, which is reduced to the smallest dimensions.

The trunnions of the gun rest on two carrier blocks which move up and down in circular guides formed on the brackets of the carriage, the blocks being connected by a bent arm, *g*, against which the piston, *k*, of the hydraulic cylinder works. Glycerine is used in the pump. The recoil is taken by a hydraulic brake, which consists of two cylinders, *h h*¹, Fig. 4, filled with glycerine, which are fixed horizontally to the carriage, the pistons being connected with the slide.

The pressure in the hydraulic cylinder for elevating the gun can be obtained either by a hand pump fitted to the carriage or by means of an accumulator. The piston of the accumulator is raised by forcing the glycerine into the cylinder by means of the steam pump. The accumulator cylinder can then be made to communicate with the elevating cylinder in the carriage by means of pipes and cocks, J and M, Fig. 4, causing the gun to rise or fall.

As the elevating cylinder moves with the carriage, the tube or pipe connecting it with the accumulator has a sliding



COMBINED STEAM ENGINE AND FIRE PUMP.

sleeve which shares in the motion of the carriage, while the remainder of the pipe remains fixed, Fig. 8.

In the earlier carriages, when the gun was lowered the glycerine was allowed to flow into the reservoir, whence it was thrown again into the accumulator by the pump. It will be seen that one accumulator serves for several guns, and can also be used to rotate the turret. The advantage of this arrangement consists in the rapidity and security of the service of the guns, which can be elevated or depressed ten times quicker than by the hand pump, an important advantage in action.

The arrangement of the accumulator in the new carriage is of the same character. The accumulator forces the glycerine through a distributing cock, V, and conducting pipe, L, and lifts the piston, K; the improvement introduced in the new carriage consists in making use of the weight of the gun to raise the loaded piston of the accumulator when the gun is being lowered, thus reducing the work of the pumps. This is obtained by means of an arrangement, K, called the differential piston, Fig. 3, consisting of a piston which does not quite fill the cylinder, C, an annular space, D D, being left above the surfaces of contact. The distributing cock is also so disposed that the movement of a small lever on the front of the carriage, H, Fig. 7, places the annular space in communication with the accumulator, so that the downward pressure on the annular portion of the surface of piston, added to the weight of the gun, becomes greater than the load on the accumulator piston, the result being that the latter rises as the gun is lowered. As the gun is subsequently raised, an opposite movement of the lever connects the annular space with the reservoir of the pumps into which the glycerine flows. The pumps have therefore at each operation only to furnish the quantity of fluid contained in the annular space, instead of an amount corresponding with the volume of the cylinder, which greatly reduces the work of the pumps. It should be observed that the pumps can be kept going without interruption and independently of the working of the guns in action.

A further important improvement, which enables the size of the embrasure to be considerably reduced, consists in the introduction of an apparatus for directing the movement of the muzzle of the gun during the recoil. Two plates, R R¹, fixed to the gun, slide back and forward on a bronze directing bar, F F, Fig. 3. The parts are so arranged that the axis of the bore of the gun is exactly parallel to the working surfaces of the grooves in the sides of the directing bar, and as the latter can only turn in a vertical plane around the pivot, P, to which it is attached, it follows that as the gun recoils and the plates slide along the bar, the axis of the bore makes a slight movement of rotation round the trunnions, and consequently the gun disengages from the embrasure without touching it. The embrasure can therefore be made closely surrounding the chase of the gun, whereas formerly it had to be made much larger in order to allow for the irregular movements in recoil.

This apparatus works with great accuracy and precision. In comparison with other arrangements, it has the advantage of preventing any "jumping" of the gun when fired, and consequently insures an accurate movement of the gun upon the slide. At the same time the recoil is exactly regulated and the precision of fire increased.

These advantages have been verified during firing trials. On discharge the gun recoils easily along the directing bar. When fired with extreme elevation of 25 deg., the simple and effective action of the bar in causing the muzzle of the gun to dip and pass through the exceedingly narrow embrasure is specially noteworthy. The carriage recoils a short distance up the slide and then automatically runs down again into the position of firing. This return of the carriage "into battery" occurs after each round with great precision. The action of the directing bar brings the gun back to it. exact original elevation, which greatly increases the rapidity with which fire can be maintained, as no time is lost in relaying the gun.

In the smaller carriages two hand levers work the pumps, one on each side of the carriage, and afford room for six men to raise the gun. With the 5·9 in. gun the time required to raise it by hand from extreme elevation to extreme depression, an arc of 25 deg., is about 80 seconds.

With regard to the chance of a shell entering the embrasure, it is clear that with the Gruson embrasures this is reduced to a minimum. This danger is very much greater in the case of the large openings forming the embrasures in the English armored batteries, which are 4 ft. high and 2 ft. 9 in. wide. Even with the so-called "armored cannon" designed by Krupp, where the muzzle of the gun works in a ball-and-socket joint, a shot striking at the juncture between the ball and the surrounding armor might entirely prevent the further working of the gun. The Gruson turret as now constructed possesses a greater degree of security in this respect than any other system of armor, for not only does the embrasure surround the chase of the gun so closely as almost to touch it, but a shot striking at that point would encounter two hard surfaces, one of chilled iron, the other of steel, and consequently there would be a better chance of escaping a jam than with other materials.

The salient advantages of the Gruson system are the following: Compactness; simplicity of construction; absence of bolts or backing; absence of splinters; practical immunity against ingress of shot or portions of shell; special property of deflecting harmlessly a large proportion of the shot which strike; practically undiminished defensive power long after the shields are severely injured; and, consequently, defense can be maintained longer than with other systems.—*Engineering.*

MARCILLY'S NEW COPPER-PLATE PRINTING PRESS.

THE invention of the mechanical press represented in the two accompanying plates marks a great advance in the art of copper-plate printing. The apparatus, which is the invention of Mr. H. F. Marcilly, of Paris, is shown in longitudinal elevation and in plan and end elevation respectively by Figs. 1, 2, and 3 of Plate 1. Fig. 9, of Plate 2, is a vertical section made through the axis of the press.

The machine, as a whole, is supported by a frame, B. In the rear there is arranged an inking roller, E, which, through a mechanism to be hereafter described, deposits ink upon a cast iron table, D, called the "marble." This latter, as well as the frame, C¹, upon which the engraved plate is fixed, is supported by a carriage, A, which has a rectilinear to and fro motion of 2·2 m.

When the carriage begins its motion toward the right, carrying with it the inked marble and plate, the latter first passes under the first cushion or pad, *h*, which effects a preliminary wiping, then under two inking rollers, d^3, which are at this moment raised so as not to come in contact with the plate. The wiping of the plate is effected by two dry and two damp cushions, *f*, after which it passes under the pressure cylinder, *k*, which carries the paper over the engraving so that it may next be printed. During this travel of the carriage, A, and its accessories, the marble, which is placed a little lower than the plate, has passed first under the cushion, *h*, then under the inking rollers, d^3, and finally under the finishing cushions, *f*, without touching any of these parts. On its return, after the pressman has removed the proof that has just been made, the marble passes again, first under the finishing cushions, *f*, which are at this moment raised so as to allow it free passage, and then slightly lifts the inking rollers, d^3, upon which it deposits the ink that it has received at the start, and, continuing to be carried along by the carriage, A, it passes again under the wiping cushion, *h*, but without touching it.

During this retrograde motion, the engraved plate has at first disengaged itself from the pressure cylinder, K, and passes under the cushions, *f*, which are kept lifted, then becomes inked by contact with the rollers, d^3, and undergoes its first wiping from the cushion, *h*. After having thus returned to its starting point, the carriage is again drawn toward the right, and the same operations are again gone through with in the same order.

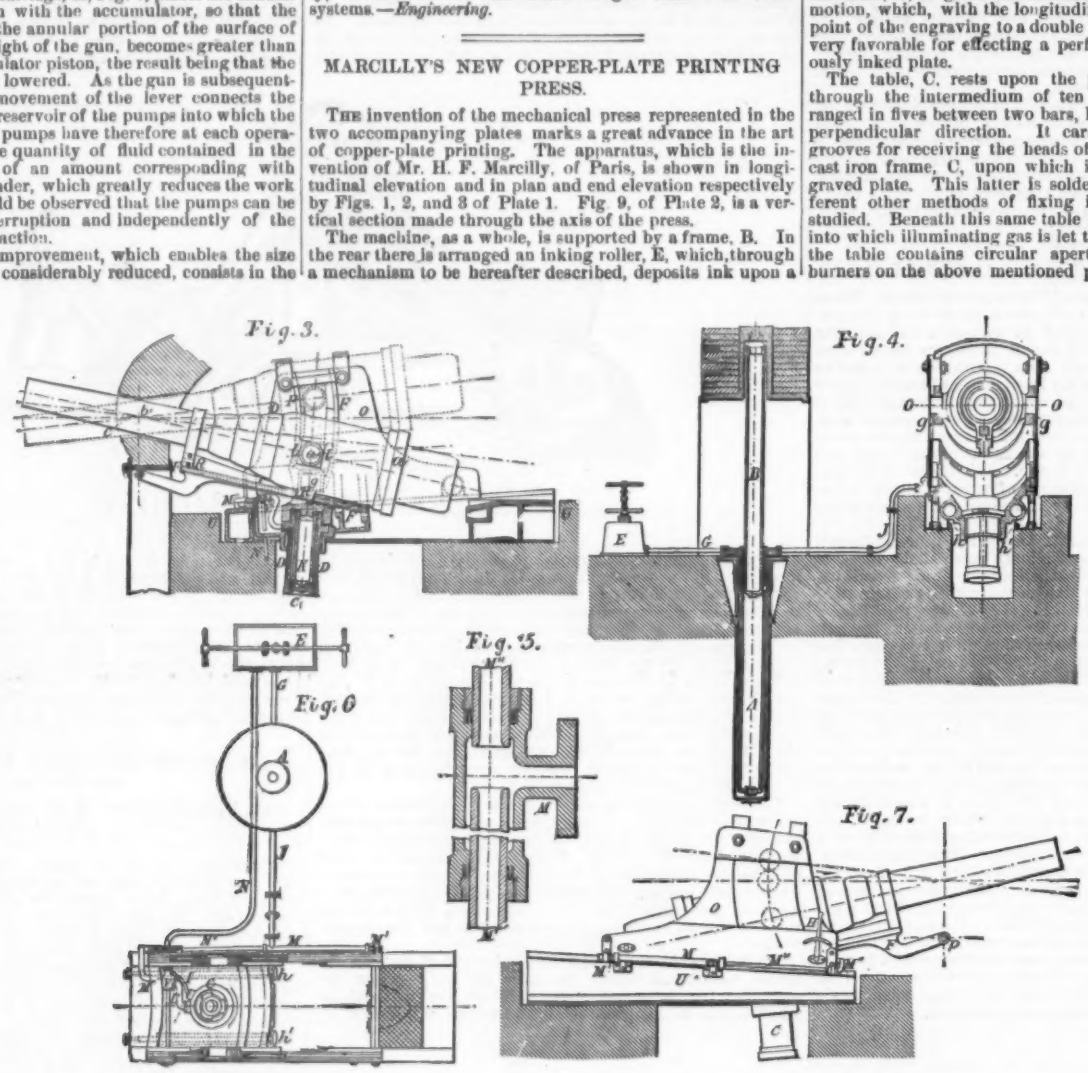
The Carriage and Table.—It will be seen from Fig. 5, which is a transverse section of the carriage, A, that the latter rests upon each of the well squared upper surfaces of the longitudinals, b^2, through the intermedium of eight cast iron rollers, *a*, whose axes are united by bars of iron, a^1. This general arrangement is free lengthwise, and is carried along by the carriage, A, when the latter moves longitudinally. Lateral displacement of the carriage is prevented by two flanges cast in a piece with it.

Fig. 4 shows the arrangement of the carriage longitudinally, and Fig. 5 transversely. It consists of a platform, A, and a rib, A^1, to which is fixed a rack, A^2. The platform is traversed by two bolts, a^3, each of which holds a flat bar, A^3, which is capable of oscillating in a horizontal plane around its axis.

From Fig. 6, which is a horizontal section on the line 3-4 of Fig. 4, it will be seen that these bars being united at their extremities by the crosspieces, a^3, and a^4, constitute a parallelogram, which pivots around the axes, a^2. The crossbar, a^3, is in two parts that are united by a vertical axis, *c*, which is screwed to the under side of the table, C, upon which is fixed the frame that receives the engraved plate. These details are shown in Fig. 7, which is a vertical section made on the line 5-6.

The bars, A^3, carry at their free extremity two rollers, a^4, which rest laterally upon two guides, b^3, fixed against the longitudinals, b^2. These guides are corrugated for a portion of their length; and the result is that, during a portion of the longitudinal travel of the carriage, the parallelogram is forced to oscillate around the axes, and that, consequently, the table, C, is given an alternating, to and fro, transverse motion, which, with the longitudinal one, gives rise at each point of the engraving to a double undulating motion that is very favorable for effecting a perfect wiping of the previously inked plate.

The table, C, rests upon the platform of the carriage through the intermedium of ten rollers, c^1, which are arranged in fives between two bars, like the rollers, *a*, but in a perpendicular direction. It carries, in both directions, grooves for receiving the heads of the bolts that hold the cast iron frame, C, upon which is directly placed the engraved plate. This latter is soldered to the frame, but different other methods of fixing it thereon are now being studied. Beneath this same table there are fixed pipes, c^2, into which illuminating gas is let through rubber tubes, and the table contains circular apertures that correspond to burners on the above mentioned pipes. This arrangement



IMPROVEMENTS IN GUN MECHANISM AND EMBRASURES.

permits of giving the frame and engraved plate the necessary temperature for facilitating the inking.

The machine receives its motion from the shafting through a belt running over one of the two pulleys, P P¹—one of them loose and the other fast upon the shaft, *p*, which carries likewise a fly wheel, V, and a pinion, p^1 (Figs. 3, 10, 11, and 12). The shaft, *p*, is connected by a double joint, Q, with a second shaft, q^1, placed obliquely (Fig. 3). To the free extremity of this latter is keyed a pinion, q^1, which actuates the large face wheel, Q, mounted loosely on the shaft, *r* (seen in part in Fig. 11). This wheel, Q, is toothed, and engages with a pinion, Q^2, which is keyed upon the shaft, q^3, as seen in front view in Fig. 12. Upon this same shaft there is fixed a pinion, q^4, which actuates the rack, A^2 (Fig. 9).

When the carriage, A, has completed its entire travel, the motion must be reversed so that it may return to its starting point. To effect such reversal, it is only necessary to cause the pinion, q^4, to pass from the interior to the exterior of the wheel, Q^1, and in that portion of the latter where the teeth have been suppressed in order to leave the passage completely free.

The position of the different members in Fig. 12 corresponds to that chosen for the figures in general, that is to say, the plate, which has been inked in the return motion, is about to be carried again toward the wipers placed near the center of the machine, and the pinion, q^4, which has just actuated the external crown or face wheel, is now upon the point of passing to the interior. The very original means used to effect this movement we shall now describe.

The shaft, *q*, carries two bearings that are capable of sliding in a guide, Q^4, cast in a piece with the support, Q^5. This shaft, which is capable of oscillating around its articulation with the shaft, *p*, and in a plane parallel with the guide, Q^4, passes freely through a large skew collar, Q^6, which is fastened at one extremity to a bush mounted loosely upon the prolongation of the nave of the crown wheel, Q^1. This bush or socket is cast in a piece with a lever, Q^7, which is held nearly vertically by a spiral spring, Q^8, during the entire travel of the carriage and its accesso-

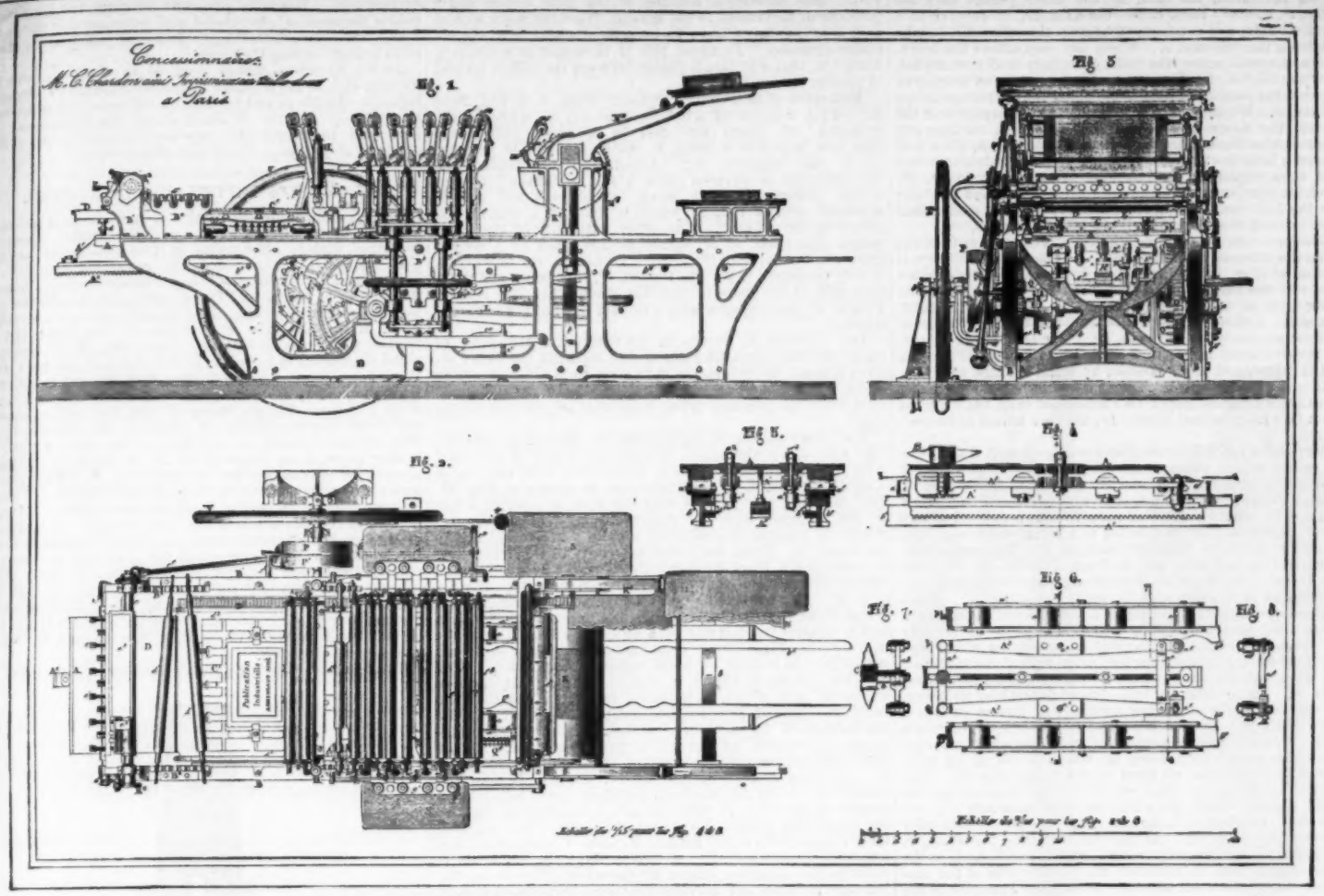


PLATE 1.—MARCILLY'S COPPER-PLATE PRINTING PRESS.

ries, and which is moved from such a position only at the moment that a mass or tappet, q^2, cast in a piece with one of the spokes of the wheel, Q, comes in contact with a projection on the said lever. This contact takes place only at the end of the travel.

Upon the same shaft, r, with the face wheel, Q^1, is keyed a toothed wheel, p^2, which is actuated by the pinion, p^1, and a large cam, R, that acts upon the small pulley, r^4, mounted loosely upon the shaft, q. This cam is so arranged that it disengages the pulley, r^1, and allows the shaft, q, to slide in the guide, Q^4, at the precise moment that the toothless part of the wheel, Q^1, comes opposite the pinion. q^1, which latter can then pass through such free interval, from the exterior to the interior of the wheel, Q^1. This phase in the motion is shown in Fig. 12. At the beginning thereof, the tappet, q^2, meets the lever, Q^3, causes it to oscillate from right to left, and thus forces the collar, Q^2, to rise. This latter then causes the shaft, q to enter the guide, Q^4, as it already had a tendency to do through its own weight. The pinion, q, continuing to revolve in the same direction, pivots on the last tooth, q^2, in order to pass into the interior of the wheel, Q^1, and causes the latter to reverse its motion and revolve in the same direction with it. As a result of this change of direction, the contact ceases between the tappet, q^2, and the projection on the lever, and this latter then resumes its vertical position, and the collar, Q^2, descending again, leaves the shaft, q, free to descend to the bottom of the guide, Q^4. The carriage and its accessories are then carried under the wipers, and next under the pressure cylinder.

Inking Mechanism (Figs. 1 to 3, 9 and 13).—The ink-trough consists of a reservoir, E, against which rests a cast-iron cylinder, e, and which may be removed from or brought close to the latter by means of screws, e^1. The ink carried along by the cylinder, E, is taken up by a copper roller, E^1, which is mounted upon an iron axle supported at its extremities by levers fixed upon a parallel axis, e^4, upon which also is fixed another lever, e^3, that carries at its extremity a small roller resting against a cam, E^3, mounted at the end of the cylinder, e. The cylinder, e, carrying along

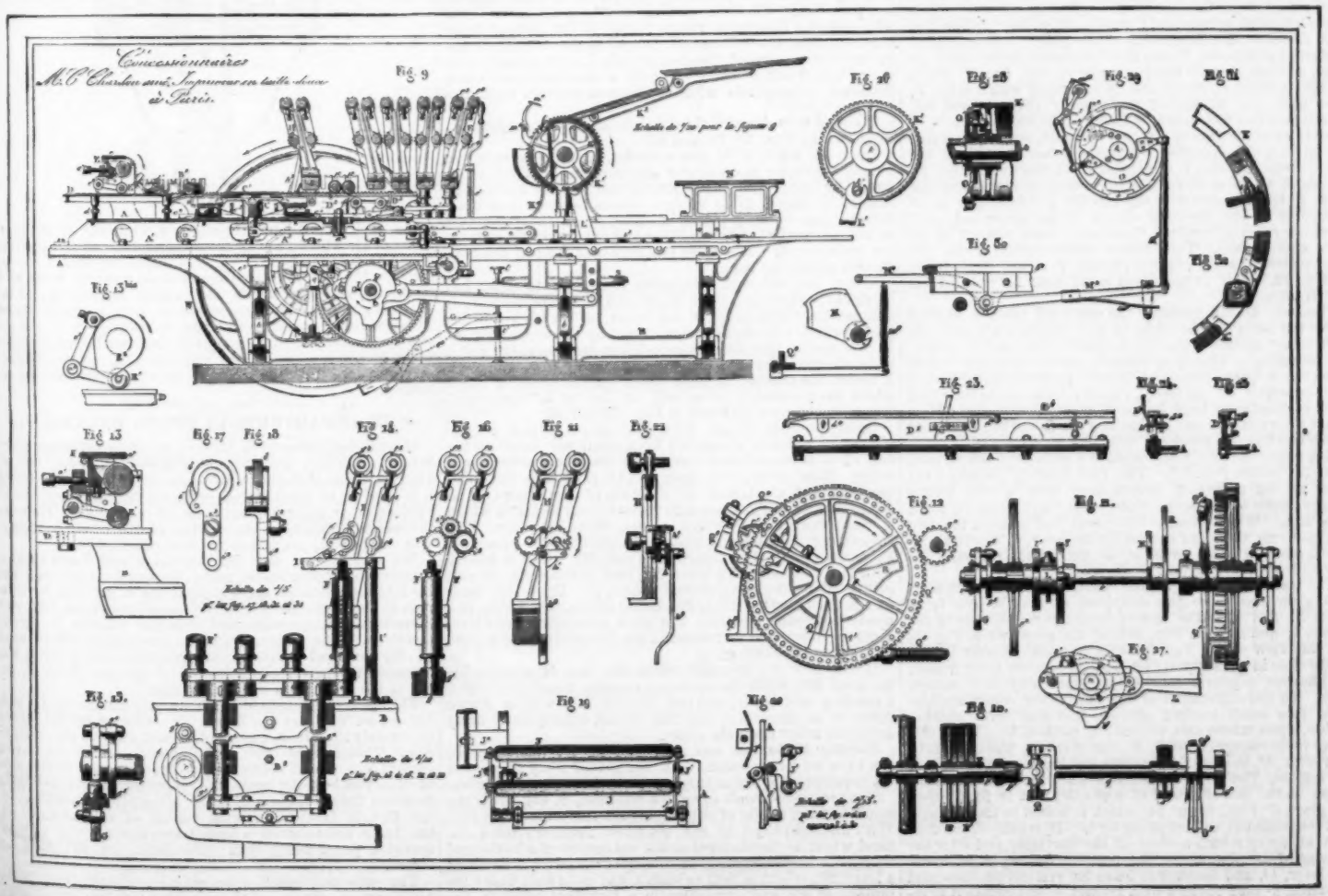


PLATE 2.—MARCILLY'S COPPER-PLATE PRINTING PRESS.

in its revolution the cam, E^3, the latter pushes back the lever, e^5, at every turn, causes the axle, E^4, to revolve to a certain angle, and consequently forces the roller, E^1, to take ink from the cylinder, e. When the cam allows the lever, e^5, to descend again, the roller, E^2, falls and spreads ink over the marble, D. This layer of ink is rendered more even through the passage of the marble under the copper spreading rollers, d^1. While the ink is being spread uniformly over the marble, the latter is being carried along by the carriage and passes under the cushions, h, without touching it, since it is placed a little lower down than the engraved plate that has just been wiped by the cushion. The inking rollers, d^2, are kept lifted during the passage of the plate and marble; but the four cushions, on the contrary, are depressed at that moment and complete the wiping off of the plate.

The rotary motion of the cylinder, e, is effected as follows:

To the extremity of the shaft, r, is keyed a small bevel-pinion, r^6 (Fig. 11), which, engaging with another similar one, actuates the obliquely placed shaft, c^6 (Fig. 9), and this latter sets in motion another one, c^7, which, in its turn, transmits motion, through bevel-pinions, to the cylinder, e, and consequently to the cam, E^3. The two inking rollers, d^2, revolve freely in bearings carried by supports, D^3, bolted to the frame, and are held down by spiral springs, d^3.

In order to keep the ink from spreading beyond the plate, and thus soiling the paper, two guides, d^4 (Fig. 14), are fixed upon two longitudinal pieces, D^2, that are bolted to the carriage.

Mechanism for Wiping the Plates.—(Figs. 1 to 8, 9 and 14 to 22).—The wiping cushions are covered beneath with leather over which passes muslin, and are each fixed to the base of frames whose mechanism is shown in front and back view in Figs. 14 and 16. Each of these frames is formed of two pieces of cast-iron, F, and bolted to a horizontal cross-piece, f^5, under which is fixed the cushion, f. The cross-piece, f^5, carries on each side, and in front of the lateral pieces of the frame, a rectangular piece through which it is bolted to a plate cast in a piece with the hollow cylinder, F^1. Each of these cylinders is placed upon a vertical rod, g, and rests upon a strong spiral spring wound around the latter. By this means the entire arrangement is suspended elastically. The four rods, g, placed on the same side of the machine, are fixed upon a cross-piece, g^1, supported by two strong rods, g^4. These latter are cross-braced beneath by the piece, g^2, and are capable of sliding vertically in bushes cast in a piece with the upright, B^2. The cross-piece, g^3, carries a roller, through the intermedium of which the entire arrangement rests upon a large lever, G, which pivots at its right extremity around an axis fixed to the frame (Fig. 1). This lever is bent at its other extremity, and supports at this point a small roller, g^4, which rests against a cam, g^5, and this latter is keyed to a shaft, r (Fig. 11), whose extremity traverses the lever, G. At each revolution of this shaft, r, the lever, G, is alternately raised and lowered, and, as the same arrangement is repeated at the other side of the machine, there results an alternate raising and lowering of the four frames, and consequently of the four cushions. As already stated, whenever the wiping cushions are down, the inking rollers are raised, and *vice versa*. The connection between these different members is shown in Fig. 1. The last of the rods, g, to the left side carries beneath a horizontal pin, which, when the four wipers fall, causes a small lever, d^5, to lift, through the intermedium of a connecting-rod, the cross-piece, d^6, upon which rest the bearings of the rollers, d^2. The result is that these latter are lifted during the passage of the previously inked plate.

The muslin that covers the cushions is mounted and renewed in the frames as follows: The two lateral sides, F, of each frame are traversed by the journals of two pairs of iron rollers, f^2, f^3, and, f^4, f^5, arranged horizontally and united, two by two, through an endless belt. One of the extremities of the muslin is sewed to the belt to the right, and winds about it a great number of times. The muslin afterward passes under the cushion and is fixed to the endless belt to the left, and subsequently unrolls, about four millimeters of it at a time, at each passage of the plate. This unrolling is effected as follows: To the front extremity or the roller, f^3 (Figs. 4 to 18), there is fixed a small ratchet, i, with which engages a click, i^2, whose axis is connected with a lever, i^3, loose upon the journal of the roller, f^1 (Figs. 19 and 20). At one point of this lever, which may be changed at will, there is fixed the axis of a roller, i^4, which rests upon a horizontal bar, I, supported by two columns, I^1. When the frame drops, the bar, I, remaining fixed, the small lever, I^1, is obliged to move toward a horizontal position, and the click, i^2, that engages with the ratchet, i, forces the latter to revolve in the direction shown by the arrow and carry along the rollers, f^2 and f^3, these latter being covered by the same endless belt. This motion is transmitted to the two other rollers, f^4 and f^5, by the pinions, i^5, i^6, and i^7, as shown in Fig. 16. This arrangement is the same for each of the four frames.

Precisely at the moment the engraved plate is passing under the cushions, the table, C, that supports it is given an undulatory motion which is repeated under each cushion, this imitating as closely as possible the motion that occurs when the wiping is done by hand. In order that the plate shall be wiped off perfectly, the two cushions to the right must be constantly kept damp. The mechanism that effects this is shown in plan and section in Figs. 19 and 20. The front of the carriage is provided with two small bearings, into which passes the axle, j, and upon this latter are fixed, at each side, the levers, j^1 and j^2. The two levers, j^2, support the axles of the rollers, J, which have been wound with a shaggy fabric that absorbs water easily and retains it for a long time. When these rollers come just beneath the two last cushions, the roller carried by the lever, j^2, meets an inclined plane, J^2, that forces it, as well as the rollers, J, to rise and wet the cushions.

The frame of the first wiping cushion, h, has not the same arrangement as those just described, as may be seen from Figs. 21 and 22. The first of these figures represents the frame, h, and as seen from behind the press, while Fig. 22 is a side view of it. This frame is mounted directly in one of the slots in the support, D^2, and its position never varies. It, likewise, supports four rollers that carry two endless belts. To the extremities of the two lower rollers are also fixed two small toothed pinions, that gear with another pinion, upon whose axis is fixed a ratchet, h^1. With this latter there engages a click, h^2, that pivots at the extremity of a lever, h^3, bent at right angles and loose upon the axis of the ratchet. The lever, h^3, is bent toward the base, and is situated on the line of travel of a pin, h^4, that is fixed upon the piece, d^6 (Figs. 23 and 24), which is bolted to the carriage, and consequently carried along by it. It results from this, that at every return motion of the carriage, and after the passage of the plate under the cushion, h, the pin, h^4, meets the lever, h^3, and causes it to leave its vertical position; and the click, h^2, then engages with ratchet, h, and causes it to revolve, thus effecting a rotation of the four rollers and a consequent movement in the muslin. Were the latter wound as it is in the other frames, its movement would be in the opposite direction. To avoid this it is wound in a contrary direction, that is to say, it passes between the rollers instead of passing externally.

Mechanism of the Pressure Cylinder (Figs. 1, 2, and 26 to 31).—This consists of a hollow cylinder, K, with the extremities of which are cast in a piece two naves that are keyed to a shaft, k, which revolves in bearing, k^2, in the supports, K^2. About half the surface of this cylinder is covered with a felt "blanket," one of whose extremities, after being turned back and sewed, is passed over a rod, k^4, which is fixed in a longitudinal groove in the cylinder. The other extremity of the felt is wound over a bar, k^5, of square section, fixed in a second groove in the cylinder (Fig. 31). To tauten the blanket, it is only necessary to revolve the bar, k^5, this being unable to turn back in the opposite direction, seeing that it is held by a click, k^6, that engages with a ratchet fixed at the bar's extremity.

The cylinder, K, carries in its revolution the sheet of paper over the engraved plate at the moment the latter arrives beneath the cylinder. After an impression has been taken, and the carriage is traveling back again the plate must pass under the pressure cylinder without any contact taking place.

The rotary motion of the cylinder is effected as follows: The axle, k, to which the cylinder is keyed, is provided with a gear wheel, k^1, that is unprovided with teeth upon a small portion of its circumference, as shown in Fig. 26. Into the felly, and parallel with this axle, is inserted a pin, k^3, that engages with the upper extremity of a lever, L^1, which is capable of oscillating around a horizontal axis in the frame, B. From the lower extremity of this lever there is suspended a large connecting-rod, whose head carries an elongated aperture that gives free passage to the shaft, r (Fig. 9). This connecting-rod head carries two small rollers, (l^2 and l^3), arranged at its two ends, and opposite one another, and in contact respectively with the cams, l and l^1, upon the shaft, r (Fig. 27). These cams are so arranged that both are always in contact with the corresponding rollers. The position shown in Fig. 9 is that of starting. At this moment, the gear wheel, k^1, is placed in such a way that the toothless part of it points downward. We shall suppose the carriage to be in motion and shall follow the simultaneous movement of the parts just mentioned. At the beginning of the carriage's travel, the cam, l, revolving in the direction shown by the arrow, the rod, L, does not budge, but is, on the contrary, repulsed to the left, when a contact of the roller, l^3, with the cam, l, occurs to the right of the projecting piece. The result is that the lever, L_1 oscillates from left to right around its axis of suspension, and causes the gear wheel, K^1, as well as the cylinder, K, to revolve in the direction shown by the arrow (Figs. 9 and 26). During this time, the carriage continues to advance toward the right, carrying with it the piece, D^4, whose upper part forms a rack, D^4, as seen in Figs. 23, 24, and 25.

It results from the circular motion given the gear wheel, K^1, by the lever, L^1, that the rectilinear part is raised, and that the teeth, carried downward, are caused to engage with the rack, D^4. After this, the latter, in continuing to advance to the right, causes the gear wheel as well as the cylinder to revolve; and the sheet of paper, held as we shall explain, is carried over the plate that has come beneath the cylinder.

The moment the impression has been taken, the cam wheel, l, disengages the roller, l^3, and the cam acts upon the roller, l^2, in such a way as to repulse the rod, L, quickly to the right. After that, the lever, L^1, moves toward the left and causes the wheel, K^1, which has made an entire revolution, to revolve in the direction shown by the arrow (Fig. 9). In this last position of the wheel, K^1, the rack, d^3, can pass freely when the carriage is returning toward the left. During this entire return travel of the carriage to its starting-point, the cylinder, K, as well as the rod, L, is immovable, the parts of the cam wheels, l, l, in contact with the rollers, l^2 and l^3, being precisely a circumference whose diameter corresponds with the distance between such two rollers.

We shall now describe the mechanism of the paper-clip, o^2, shown in Figs. 28, 29, and 30.

Upon the shaft, k, of the cylinder, K, there is mounted loosely a disk, O, upon one of the surfaces of which is affixed by screws a plate, O^1, which carries a counter-cam so arranged as to leave a recess between it and O. Within this recess is placed a roller, o', which is mounted, at the extremity of a small lever fixed upon the axle of the cylinder, K. It is upon this axle that is fixed the clip, o^2, that grasps the paper.

When the carriage, advancing from left to right, has brought the plate under the wiping cushions, and the plate is approaching the cylinder, k, the latter, as has been said, begins to revolve in the direction shown by the arrow (Fig. 9). In this motion, the disk, O, remaining stationary, the roller is drawn out of its recess, and, moving away from the shaft k, forces the clip, o^2, to shut down on the sheet of paper which has previously been laid out flat by a "spreader," whose mechanism is shown in Figs. 29 and 30.

Upon the disk, O, are fixed two pieces, m and m^1, the former of which is connected by a small rod, m^2, with the end of a lever, m^3, that carries at its other extremity a roller. This lever pivots upon an axis carried by two small brackets that are bolted to the base of the checks, k^3, of the feed-table. The same axis carries small levers to which is fixed the clip, o^2, which serves, with the roller, I, to smooth out the sheet of paper presented by the pressman. From the piece, m^1, is suspended a rod, M^3, which is jointed with the extremity of a lever, M^2, that pivots upon an axis supported by the longitudinal pieces, b^2. Upon this same axis is fixed another lever, M^1, that a spring, m^5, holds in a nearly horizontal position. The other extremity of this lever carries a roller that is situated in the line of travel of a cam, M, fixed to the shaft, r.

It will now be seen that when the cam, M, approaches the lever, M^1, while the carriage is running from left to right, a meeting will occur, and that the rod, M^3, will be drawn down so as to revolve the disk, O, and consequently bring down the roller upon the paper.

Gearing Mechanism and Brake.—This machine may be run by a single pressman, with the aid of a boy to remove the impressions as fast as they issue from beneath the cylinder.

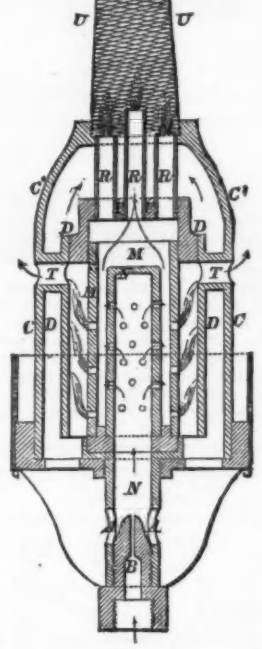
The pressman stands upon the platform, S, and feeds the machine from a pile of paper lying on the table to his left. With his right hand he can act when necessary upon the hand-wheel, s, that is fixed at the extremity of a horizontal shaft, s^1. On the opposite extremity of the latter is mounted a lever, S^1, which is bent in such a way as to pass under the pulleys, P, P^1, and terminates in a fork that takes in the driving belt. When the pressman actuates the lever, s, he causes the shaft, s^1, to revolve and consequently moves the fork, which then shifts the belt from one pulley to the other, so as to start or stop the press.

As the fly-wheel makes from 50 to 60 revolutions per minute, and as the carriage in the same length of time performs its double to and fro motion six times, the machine is theoretically capable of taking about 350 impressions per hour; but in practice this number is reduced to about 300, owing to stoppages.—*Publication Industrielle.*

CLAMOND'S IMPROVED GAS BURNER.

THE accompanying illustration shows a vertical section of this last construction of burner and the heating apparatus combined with it. It consists of two concentric casings, C D, formed of ceramic material, connected together by hollow ties, T, which establish a communication between the interior of the casing, D, and the space outside the casing, C. Centrally within these casings are two concentric tubes, M N. The tube, N, is closed at the top; and is pierced with holes on its sides. The tube, M, is also provided with holes in its sides; and is closed at top by a cap, F, having a number of small tubes, R R, of ceramic material. B is an ordinary Bunsen apparatus for producing a mixture of air and gas. The gas issues through the orifice shown, and draws in atmospheric air through the openings, A. This mixture ascends through the central tube, N; and in issuing through the openings in it (in small jets) strikes against the internal surface of the tube, M. The greater part of the mixture rises up through the tubes, R, and enters into combustion on issuing from the tops of them. Another portion of the mixture issues in jets through the openings in M, and, being ignited, heats the annular space between the tubes, M and D, from which the resulting products of combustion escape through the openings, T. The atmospheric air surrounding the burner rises up through the annular space between C and D; and, after becoming heated therein, enters into combustion with the mixture of gas and air as it issues from the tubes, R, within the cage, U, formed of magnesia threads.

The combustion of the gaseous mixture issuing from the



tubes, R, is effected entirely within the interior of the cage. The hot air which rises up from the annular space between C and D, into the hood, C^1, passes thence between the bundle of tubes, R. It therefore surrounds each of them as it passes up, and thus effects the perfect combustion of the gaseous mixture issuing therefrom in a very small space. This condition, together with that of heating the air and gas supply, is (the patentee says) very essential for obtaining a vivid incandescence of the magnesia. A glass chimney serves to accelerate the draught, as well as increase the air supply.

NEW DEPARTURES IN PHOTO ENLARGING.

HAVING been present in London at a demonstration given before a brilliant assembly by Professor Stebbing and M. Hutinet, both of Paris, to prove the great facility by which it is possible to produce enlargements without any special appliances or apparatus but those of the simplest kind, we proceed to give such a description of the whole process as will, we believe, prove acceptable to our readers.

We may premise that M. Hutinet, a well known manufacturer of photographic paper, having for some time had his attention directed to the substitution of gelatine for albumen in the preparation of ready sensitized paper, has now completed arrangements and obtained patents in several countries. The demonstration in question, at which most of the principal London photographers were present, was intended to show the application of the new kind of paper to the production of enlargements.

The apparatus consisted of a lantern, in the center of which burned an ordinary gas flame. A reflector behind served to strongly illuminate a plate of ground glass on the opposite side. This formed the dark lantern. A second box or camera was placed contiguous to the first, and in one side of this was held the negative to be enlarged, a lens having facilities for adjustment of focus being placed opposite. A few feet in front was erected a sheet of card upon which the focus was received, a large frame containing a sheet of sensitive paper being then substituted for the focusing screen.

The exposure lasted five minutes, this duration being necessary on account of the enlarging lens employed being

a slow one instead of a portrait lens, by which an exposure of one minute would have sufficed. The development was effected by means of ferrous oxalate, the general treatment and formulas not differing in any important respect from those employed in developing negatives. The tone of the finished enlargement, which, when fixed, was handed around for inspection, was good, the blacks being vigorous and the lights clear.

We think it exceedingly likely that this system will come into general use, especially for such purposes as those to which the collodion transfer process is now applied.

For amateur enlarging in the evenings, this method will be all that is wanted; for the simplicity and certainty of the whole system is such as to render its practice very much of a pastime. We have seen enlarged landscapes produced by the method described, when suspended upon the wall, look like exquisite engravings, to the tones of which they have a great similarity; and yet the originals of these are only small negatives taken in a portable camera.

For professional portraitists it will afford the means of portrait enlargements being executed after evening sets in, and when such work will not be interfering with the regular duties of the day.

We have referred to the fine quality of the tones. This is owing in a large degree to the employment of a solution of hyposulphite of soda and alum in the following proportions:

No. 1.

Hyposulphite of soda.....2 ounces.
Water .....8 "

No. 2.

Alum .....½ ounce.
Warm water.....2 ounces.

When dissolved, add these two solutions together, and allow to stand for twelve hours before using. Immerse the pictures in this for fifteen minutes, and complete the operation by fixing in a bath of hyposulphite of soda 2 ounces, water 10 ounces, prepared fresh each time. The former of these baths keeps well for a long time. It is, of course, understood that the prints must be slightly washed after development, before they are immersed in the toning bath just described.

We have been very favorably impressed by this process and system of enlarging, and have little doubt that it will, before long, be extensively practiced. The paper is always ready at hand; for, like gelatine plates, it keeps for an indefinite period, provided no light be allowed access to it. More will probably be heard of this before long.—*Photo Times.*

THE ELECTRIC TRAMCAR OF THE FRENCH ELECTRICAL STORAGE COMPANY.

THE electrical tramcar run by accumulators that we are about to describe is the first automatic electric vehicle of the kind, in the full sense of the term, that has been constructed. It was operated for the first time about two years ago, but recent experiments with it have permitted the progress that has since then been made in the manufacture of accumulators to be presented under a striking form.

The car, properly so called, is of the largest size that the Compagnie Generale des Omnibus, of Paris, builds, it being capable of holding fifty-two passengers. Although it was not built especially with a view to be run by electricity, no important modification of its parts had to be made that would render it unfitted for use on an ordinary tramway. But it required all the mechanical skill for which Mr. Raffard (the engineer who directed the changes) is noted to adapt to, and fit into, a space which was often very circumscribed, and apparently insufficient, all the pieces that constituted the simple and ingenious mechanism which we shall now describe.

Near the platform and beneath the floor of the car there is fixed a Siemens dynamo of the type D_2, which receives an electric current from a series of 80 accumulators placed under the seats, and which drives, by means of a belt and of a pulley having a differential motion, an intermediate shaft. Two pinions at the extremity of the latter, two pitch chains, and two face wheels complete the transmission. The pulley with differential motion is loose upon the shaft. Two small bevel pinions, loose upon an axle that occupies the diameter of the pulley, gear, each of them, with two bevel wheels. One of these latter is keyed upon the shaft, and, through the intermedium of a pinion keyed upon the same shaft, communicates motion to one of the wheels, while the other is loose and actuates the other wheel direct through the aid of another pinion cast in a piece with it.

One of the driving wheels of the hind axle is fixed, while the other is loose. The same is the case with the wheels on the axles of the fore-carriage, which latter is driven by a pinion and toothed segment. Owing to this combination of a differential motion and loose wheels, it is possible at every instant, on a curve, to proportion to the resistant work the motive stress applied to each wheel, so as to give the mechanism, as a whole, perfect flexibility. Friction is also rendered exceedingly slight in the said curves, as it likewise is in that rocking motion which is inevitable at certain portions of the road that chance to be bad, and which, being then transferred into a simple variation in the angular velocity (of alternately greater or smaller amount in the two wheels of the same axle), can no longer cause sliding on the rails.

The following are the results that have been obtained with this machine in two of the most important of the numerous experiments that have been tried—one of these having been performed on rails and the other on an ordinary road.

On the 24th of June last, at 4 o'clock in the morning, the tramcar started from Place de la Nation, carrying thirty passengers over the line of the external boulevards, and after crossing over uneven surfaces and ascending grades, the steepest of which reached 0 048 m. per meter, passed Place de l'Etoile, took Roi de Rome Avenue and the Trocadero and reached Muette, at the gates of the Bois de Boulogne, at twenty minutes past five. It then left the rails to return, took them again after a stoppage of half an hour, and finally reached Place de la Nation again at a few minutes after seven, after making a trip of about 32 kilometers with a mean speed of 11 to 12 kilometers per hour.

It seems to us that a few figures touching the conditions of the experiments may interest our readers.

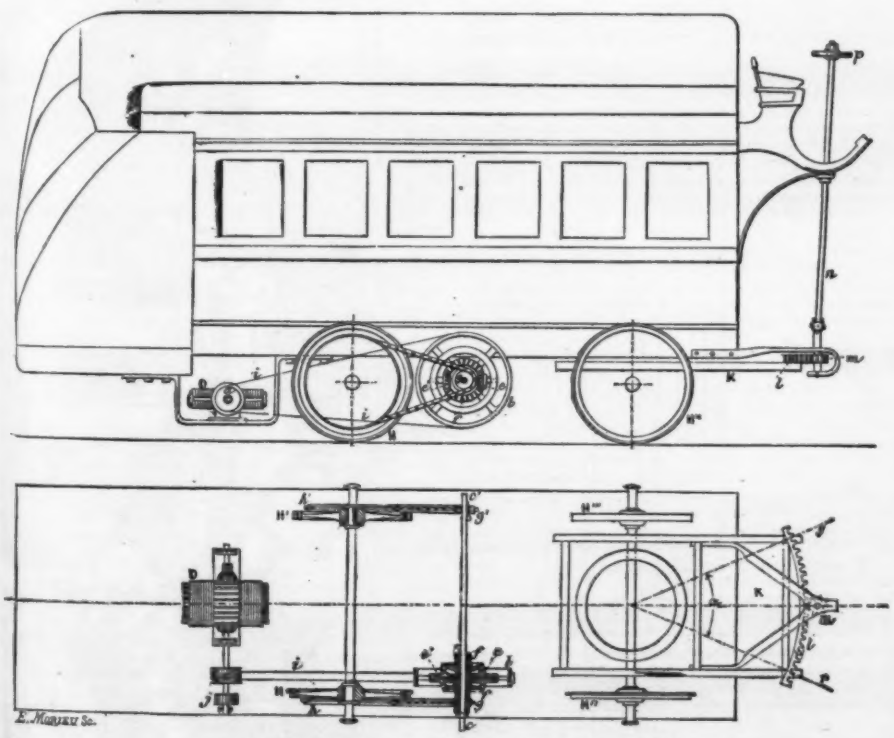
The total weight of the tramcar, including 80 accumulators of 30 kilos each, amounted to about 9 tons.

The main current was 35 amperes under 160 volts. The electric power furnished the machine by the accumulators was thus:

$$\frac{35\times160}{750}=7{\cdot}5 \text{ H.P. during } 2{\cdot}5 \text{ h.};$$

and the accumulators, notwithstanding this, were still far from being used up on return. In the second experiment, which occurred at the Champs Elysees, the tramcar worked with the greatest ease as a road machine, running without flanges on its wheels indifferently over a macadamized roadway, a wooden pavement, and a sandstone roadway, and even following the rails with the greatest facility.

We shall conclude by remarking that accumulators, through an elasticity of power that allows them to expend four or five amperes on slight grades and as much as seventy or eighty on very steep ones and in starting, and through the valuable property that they possess of taking up energy again during stoppages in order to start better afterward, are admirably adapted to locomotion, whether as regards the making of unbroken trips or, on the contrary, of making frequent stoppages and, consequently, frequent starts.—*La Nature.*



ELECTRIC TRAMCAR RUN BY ACCUMULATORS.

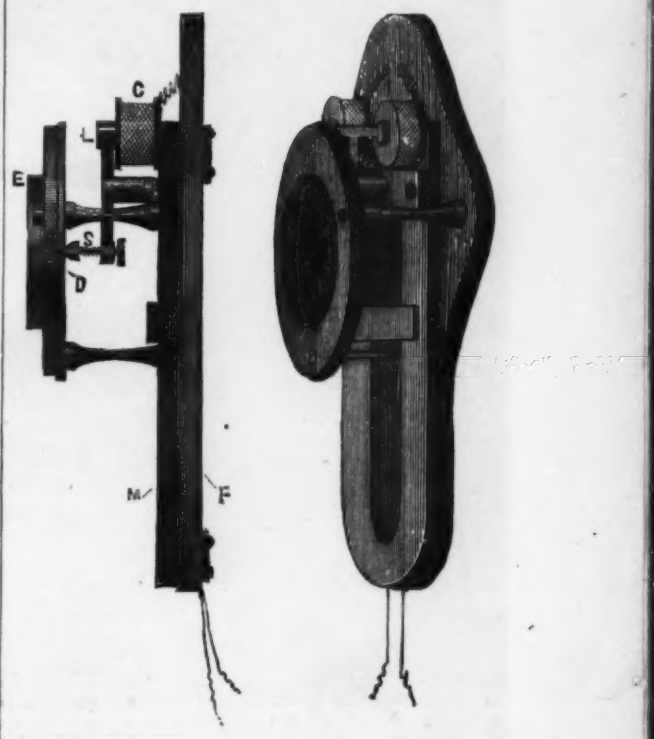
D, Siemens' dynamo, weighing 285 kilos and giving 450 kilogrammeters per second, with a current of 160 volts and 40 amperes. *a*, Pulley keyed upon the shaft of the dynamo. *b*, Pulley with differential motion, loose upon the shaft. *c c'*, Intermediate shaft. *e e'*, Bevel pinions capable of revolving freely upon axes carried by the pulley, *b*. *f*, Bevel wheel loose upon the shaft, upon the socket of which is fixed the pitch chain pinion, *g*, that drives the wheel, H. *g*, Pitch chain pinion connected with the bevel wheel, *f*. *f'*, Bevel wheel keyed upon the shaft, *c c'*. H, Flanged driving wheel keyed upon its axle, and to the spokes of which is fixed a face wheel, A, actuated by a pitch chain moved by a pinion, *g*. H', Driving wheel without flange, loose upon its axle, and carrying a face wheel, A, which is actuated by a pitch chain gearing with the pinion. *g*. Belt for transmitting motion from the dynamo to the pulley, *b*, of the differential motion. *j*, Small pulley which is acted upon by a brake so as to moderate the speed of the tramcar while on a down grade. H'', Flanged wheel keyed upon the axle of the fore-carriage. H''', Flangeless wheel loose upon the axle of the fore-carriage. *k*, Movable fore-carriage. *l*, Rack fixed to the frame of the fore-carriage. *m*, Pinion whose axle revolves in supports fixed to the body of the car. *n*, Axle of the pinion. *p*, Hand-wheel keyed upon the axle of the pinion, and by means of which the conductor steers the fore-carriage.

THE "HAMMER" TELEPHONE OF M. DE LOCHT-LABYE.

THIS telephone constitutes, it is claimed, quite a new and original arrangement for transmitting speech. It has been, up to the present, almost universally supposed that for the telephonic reproduction of speech, the employment of continuous undulatory currents is indispensable. Professor Bell is looked upon as the originator of this theory, and his great influence in the scientific world, and especially his invention of the telephone with stretched membrane or flexible disk as an application of this theory, supported him, and for the time silenced all contradiction.

It is claimed for the De Locht-Labye telephone that it has no flexible organ, no part susceptible of the undulatory movements, which are, as Bell said, the reproduction or facsimile of the sound waves of the air.

We will explain, in a few words, the construction of the receiving apparatus, which we have shown in perspective and in side elevation in the accompanying sketch. A horse-



shoe magnet, M, has at its poles two little cores of soft iron, on which are placed coils, C, of insulated copper wire. This magnet is fixed immovably to a wooden frame, F, which serves as a support to the whole apparatus. In front of the poles of the magnet, and at a very little distance from them, although this distance can very easily be regularly regulated, as we shall soon see, is an armature, consisting of a *thick, inflexible* bar of iron. This bar forms part of a *fixed lever*, L, moving freely on a *fixed axle*, placed on a little rod of copper, brass, or any other material. As we see, by its position, the armature lever is thus apparently a *free reed*, and is, in itself, in no way of the nature of a flexible disk. It is only fixed to the support by its axle, and is not connected with any membrane or other organ. It is terminated by a little hammer of metal, or some other substance, fixed to the extremity of a regulating screw, S. This hammer, in its normal position, rests upon a thick, rigid, inflexible piece of wood, glass, ebonite, or any other material, D, of any shape whatever, but which, for the sake of symmetry, has been made cylindrical in the apparatus, and to which is fitted an ear-piece, E. We must observe that, as the inventor, who is now in London, has shown us, the ear-piece may form the part which supports the hammer, which shows, he thinks, that in no way is it of the nature of a membrane or flexible disk. The position of the armature lever is determined by the magnetic attraction of the poles of the magnet, the effect of which is *counterbalanced* by the reaction of the fixed portion supporting the hammer which terminates the lever. By the help of the screw which carries this hammer, we can easily regulate the distance between the poles of the magnet and the armature, so as to obtain the maximum telephonic effect.

These are the essential characteristics of the De Locht-Labye telephone.

Bell, in his original specification (Morgan Brown patent, June 9, 1877), made the following statement:

"In all previous systems of telegraphy, messages have been received either by means of chemical changes produced by the action of the electrical current, as in the various forms of automatic and autographical telegraphs, *or by means of the mechanical movement of a portion of the receiving instrument*, operating to produce a visible signal, as in needle telegraphs, *a mark upon paper or other material, as in printing telegraphs, or a sound, as in the Morse system.*"

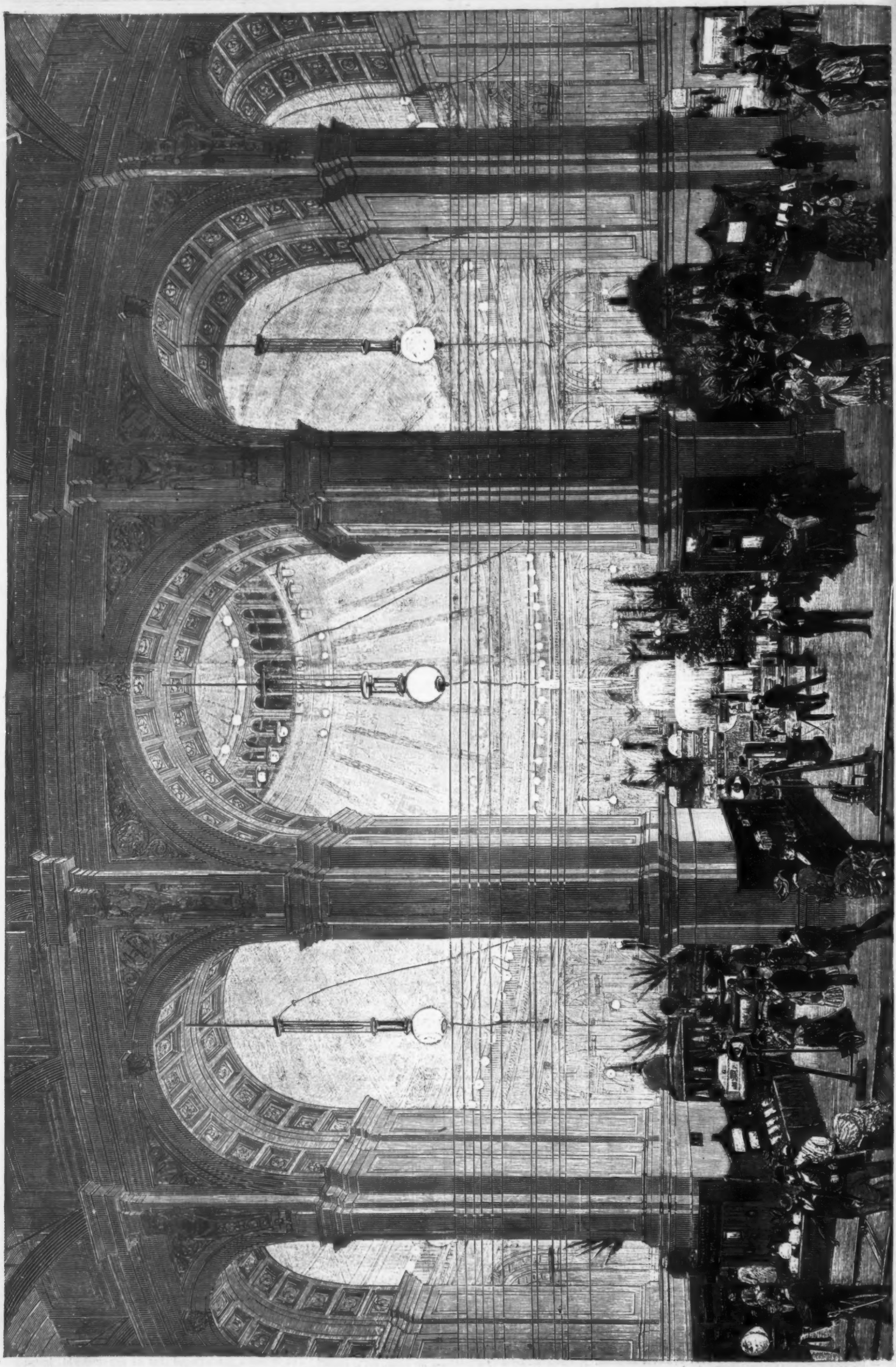
He immediately adds:

"Upon these and all other plans, *its has been found difficult, if not impossible*, to distinguish between more than four messages transmitted simultaneously over the same circuit, two in each direction;" and as Mr. Webster, Q.C., for the United Telephone Company (Limited) said, in his pleading:

"*In no single case could it be pretended that Professor Bell intended his instrument to act as reeds.*" Now, in the De Locht Labye telephone, it is claimed that the armature is a free reed. It is arranged in a manner that reminds one of the armature of the Morse telegraph, or, better still, of that of the Hughes printing telegraph; and, nevertheless, the transmission of sounds of all kinds and of speech is effected with complete success.

Numerous experiments have been made by experts with the instrument of which we give a sketch, and it is declared unanimously that it works at least as well as the Bell telephone, as regards clearness and loudness of sound.

The inventor is convinced that he can make his instruments effect far more, and that, consequently, his results will



THE INTERNATIONAL ELECTRICAL EXHIBITION, VIENNA: THE GREAT ROTUNDA.

considerably exceed those of the Bell telephone, so that his telephone can be employed for *very* long distances.

Thus, in order to show the essential points of difference between the De Locht-Labye and Bell telephones, from a mechanical point of view, one might say: That the Bell telephone is characterized by the combination of a magnet, provided with a coil or coils at its pole or poles, *and a thin and flexible plate of iron or other inductive material fixed round its edge, over all the flat circumference near and at right angle to the magnetic pole;* whereas the De Locht-Labye telephone is characterized by the combination of a magnet provided with coils at its poles, *with a rigid armature of soft iron or steel turning freely* (*as a free reed*) on an axle, and terminated by a *hammer* striking against a *rigid, inflexible* body of wood, ebonite, or any other substance. De Locht-Labye's hammer telephone can work under the same conditions as Bell's flexible disk telephone—*i. e.*, it can be employed in the double function of transmitter and receiver.

It now remains for us to explain clearly the inventor's idea of the working of the telephone as a transmitter. Every sound wave, on reaching the rigid part, imparts to it a sudden shock, which it transmits instantaneously to the hammer. The latter then separates from the rigid part and gives rise to a slight movement, the extent of which is in proportion to the intensity of the shock—*i. e.*, to the intensity of the sound. But immediately the magnetic attraction acting continuously and with great force upon the armature, stops the movement of the armature lever, and restores it to its original position, so that the movable part can receive a fresh sound shock.

These sudden movements (of the lever) of the armature before the poles of the magnet engender in the coils covering the poles *instantaneous* electric currents, equal in number to the movements of the armature, and therefore to the sound shocks. These instantaneous currents, passing through the line on reaching the end of it, are received by a similar apparatus.

The working of the telephone as receiver is then easily explained. The intermittent *instantaneous* currents, of exceedingly short duration, traversing the coils of the telephone, says the inventor, magnetize and demagnetize at each emission. If the magnetizing current is produced first, it is powerless to produce the movement of the armature lever, on account of the reaction of the inflexible body on which the hammer rests. The demagnetizing current alone is capable of drawing back the armature, and consequently of detaching the hammer from the part on which it rests. This current being instantaneous, the movement is instantly arrested by the continuous action of the magnetic attraction, which restores the armature to its original position, and forces the hammer to strike against the block. It is this shock which produces *the sound* at the receiver. For each emission of the current there is one shock, and only one. Its force is proportionate to the energy of the current, and therefore to that of the sound shock at the transmitting telephone.

All these movements are sudden, and can in no way possess a duration equal to that of a sound wave of air. This armature and the hammer are, therefore, nearly always in a position of rest, ready to receive new shocks and to transmit them to a distance.

The telephonic transmission of speech, then, according to M. De Locht-Labye, evidently results from a series of shocks, and he believes from the working of this apparatus that in order for speech and any kind of sound to be transmitted and reproduced, there must first be an equal number of sound shocks, little movements of the armature in the transmitter, and consequently of *intermittent* instantaneous currents of magnetization and demagnetization causing so many sudden movements of the armature at the receiver, and therefore so many blows of the hammer on the fixed part. There must be an exact interval of equal duration between two successive sound shocks, and finally the intensities of all these forces, the transformations of which reproduce the sound, must be in direct proportion to one another.—*Electrical Review.*

THE INTERNATIONAL ELECTRICAL EXHIBITION AT VIENNA.

THE great rotunda of the main building for the International Exhibition at Vienna in 1873 was one of the characteristic features of the buildings, and as the Magistrate of Vienna wisely concluded not to demolish this beautiful structure, it has become one of the landmarks of Vienna, and has been used for several of the local exhibitions. As it fills all the requirements of an exhibition building to perfection, it is again used for the Electrical Exhibition now open in Vienna. In the annexed cut, taken from the *Neue Illustrirte Zeitung*, a general view of the rotunda, illuminated by numerous electric lamps, is shown. The structure showing through the second arch from the middle toward the right is the pavilion of the Austrian Department of Commerce; through the second arch from the middle toward the left the Turkish pavilion appears, and adjoining the same is the French pavilion. Telephone rooms, a theater lighted by electricity, art galleries, etc., are located in the rotunda and the adjoining wings.

THE COMBINING HEAT OF CARBON AND OXYGEN.

M. BOILLOT has contributed to the Academie des Sciences a "Memorandum" upon the heat of combination of carbon and oxygen, in combustion. He remarks that in the combination formed by carbon and oxygen, in the constitution of carbonic oxide and carbonic acid, a certain amount of heat is disengaged, which has been measured. The question now is to find how this heat is divided, and how much of it is absorbed by the oxygen and carbon respectively. Two principles are involved in this determination. In the first place, it must be premised that a solid body absorbs heat in becoming liquid, and a liquid also absorbs heat in becoming gaseous. Reciprocally, a gas loses heat in liquefying, and a liquid equally loses heat in solidifying. Secondly, equal volumes of all elastic fluids, taken at the same temperature and under the same pressure, being compressed or dilated quickly by exactly the same proportion of their volume, disengage in or absorb the same quantity of heat. If, therefore, A=the heat disengaged by 2 volumes of oxygen, in forming 2 volumes of carbonic acid with the addition of 2 volumes of carbon vapor; and if B=the heat given off by 1 volume of oxygen, when forming, with two volumes of carbonic oxide, 2 volumes of carbonic acid, then A — B will be the heat disengaged by 1 volume of oxygen, to form with 2 volumes of carbon vapor, 2 volumes of carbonic oxide. Let x = the heat absorbed by 1 volume of oxygen to form 2 volumes of carbonic oxide with 2 volumes of carbon vapor; then $A - B + x = B$; whence $x = 2B - A$. If operating with 6 grammes of diamond, there will be A = 47 calories; A — B = 12·9 calories; B = 34·1 calories; and x = 21·2 calories. A + x = 68·2 calories will, therefore, be the total heat furnished by the two volumes of oxygen (weighing 16 grammes), which combine with two volumes of carbon vapor (weighing 6 grammes) to give 2 volumes of carbonic acid (weighing 22 grammes). Of these 68·2 calories there are thus 21·2 absorbed by the carbon.

CHEMICAL SCIENCE.

BRITISH ASSOCIATION, 1883. OPENING ADDRESS BY J. H. GLADSTONE, PH.D., F.R.S., V.P.C.S., PRESIDENT OF THE SECTION.

A SECTIONAL address usually consists either of a review of the work done in the particular science during the past year, or of an exposition of some branch of that science to which the speaker has given more especial attention. I propose to follow the latter of these practices, and shall ask the indulgence of my brother chemists while I endeavor to place before them some thoughts on the subject of Elements.

Though theoretical and practical chemistry are now intertwined, with manifest advantage to each, they appear to have been far apart in their origin. Practical chemistry arose from the arts of life, the knowledge empirically and laboriously acquired by the miner and metallurgist, the potter and the glass-worker, the cook and the perfumer. Theoretical chemistry derived its origin from cosmogony. In the childhood of the human race the question was eagerly put, "By what process were all things made?" and some of the answers given started the doctrine of elements. The earliest documentary evidence of the idea is probably contained in the Shoo King, the most esteemed of the Chinese classics for its antiquity. It is an historical work, and comprises a document of still more venerable age, called "The Great Plan, with its Nine Divisions," which purports to have been given by heaven to the Great Yu, to teach him his royal duty and "the proper virtues of the various relations." Of course there are wide differences of opinion as to its date, but we can scarcely be wrong in considering it as older than Solomon's writings. The First Division of the Great Plan relates to the Five Elements. "The first is named Water; the second, Fire; the third, Wood; the fourth, Metal; the fifth, Earth. The nature of water is to soak and descend; of fire to blaze and ascend; of wood, to be crooked and to be straight; of metal, to obey and to change; while the virtue of the earth is seen in seed-sowing and ingathering. That which soaks and descends becomes salt; that which blazes and ascends becomes bitter; that which is crooked and straight becomes sour; that which obeys and changes becomes acrid; and from seed-sowing and ingathering comes sweetness."*

A similar idea of five elements was also common among the Indian races, and is stated by Professor Rodwell to have been in existence before the fifteenth century B.C., but, though the number is the same, the elements themselves are not identical with those of the ancient Chinese classic; thus, in the Institutes of Menu, the "subtle ether" is spoken of as being the first created, from which, by transmutation, spring, air, whence by the operation of a change, rises light or fire; from this comes water, and from water is deposited earth. These five are curiously correlated with the five senses, and it is very evident that they are not looked upon as five independent material existences, but as derived from one another. This philosophy was accepted alike by Hindoos and Buddhists. It was largely extended over Asia, and found its way into Europe. It is best known to us in the writings of the Greeks. Among these people, however, the elements were reduced to four—fire, air, earth, and water—though Aristotle endeavored to restore the "blue ether" to its position as the most subtle and divine of them all. It is true that the fifth element, or "quinta essentia," was frequently spoken of by the early chemists, though the idea attaching to it was somewhat changed, and the four elements continued to retain their place in popular apprehension, and still retain it even among many of the scholars who take degrees at our universities. The claim of wood to be considered an element seems never to have been recognized in the West, unless, indeed, we are to seek this origin for the choice of the word ὕλη to signify that original chaotic material out of which, according to Plato and his school, all things were created.† The idea also of a primal element, from which the others, and everything else, were originated, was common in Greece, the difficulty being to decide which of the four had the greatest claim to this honor. Thales, as is well known, in the sixth century B.C., affirmed that water was the first principle of things; but Anaximenes afterward looked upon air, Heraclytus upon fire, and Theracleides on earth, as the primal element. This notion of elements, however, was essentially distinct from our own. It was always associated with the idea of the genesis of matter rather than with its ultimate analysis, and the idea of *simple* as contrasted with *compound* bodies probably never entered into the thoughts of the contending philosophers.

The modern idea appears to have had a totally different origin, and we must again travel back to China. There, also in the sixth century B.C., the great philosopher Lao-tse was meditating on the mysteries of the world and the soul, and his disciples founded the religion of Taou. They were materialists; nevertheless, they believed in a "finer essence," or spirit, that rises from matter, and may become a star; thus they held that the souls of the five elements, water, metal, fire, wood, and earth, arose and became the five planets. These speculations naturally led to a search after the sublimated essences of things, and the means by which this immortality might be secured. It seems that at the time of Tsin-she-hwang, the builder of the Great Wall, about two centuries before Christ, many romantic stories were current of immortal men inhabiting islands in the Pacific Ocean. It was supposed that in these magical islands was found the "herb of immortality" growing, and that it gave them exemption from the lot of common mortals. The emperor determined to go in search of these islands, but some untoward event always prevented him. ‡

Some two or three centuries after this a Taouist, named Weipahyang, wrote a remarkable book called "The Uniting Bond." It contains a great deal about the changes of the heavenly bodies, and the mutual relation of heaven and men; and then the author proceeds to explain some transformations of silver and water. About elixir he tells us, "What is white when first obtained becomes red after manipulation on being formed into the elixir" ("tan" meaning red or elixir). "That substance, an inch in diameter, consists of the black and the white, that is, water and metal combined. It is older than heaven and earth. It is most honorable and excellent. Around it, like a wall, are the sides of the caldron. It is closed up and sealed on every side, and carefully watched. The thoughts must be undisturbed, and the temper calm, and the hour of its perfection anxiously waited for. The false chemist passes through various operations in vain. He who is enlightened expels his evil passions, is delighted morning and night, forgets fame and wealth, comprehends the true objects of life, and gains supernatural powers. He cannot then be scorched by fire, nor drowned in water, etc. The caldron is round like the full moon, and the stove beneath is shaped like the half moon. The lead ore is symbolized by the White Tiger; and it, like metal among the elements, belongs to the West. Mercury resembles the sun, and forms itself into sparkling globes; it is symbolized by the Blue Dragon belonging to the East, and it is assigned to the element wood. Gold is imperishable. Fire does not injure its luster. Like the sun and moon, it is unaffected by time. Therefore the elixir is called 'the Golden Elixir.' Life can be lengthened by eating the herb called Huma; how much more by taking the elixir, which is the essence of gold, the most imperishable of all things! The influence of the elixir, when partaken of, will extend to the four limbs; the countenance will become joyful; white hair will be turned black; new teeth will grow in the place of old ones, and age at once become youth. . . . Lead ore and mercury are the bases of the process by which the elixir is prepared; they are the hinge upon which the principles of light and darkness revolve."

This description suggests the idea that the elixir of the Taouists was the red sulphide of mercury—vermilion—for the preparation of which the Chinese are still famous. That Weipahyang believed in his own philosophy is testified by a writer named Ko-hung, who, about a century afterward, wrote the lives of celebrated Taouists. He tells how the philosopher, after preparing the elixir, took it, with his disciples, into a wood, and gave it first to his dog, then took it himself, and was followed by one of his pupils. They all three died, but, it appears, rose to life again, and to immortality. This brilliant example did not remain without imitators; indeed, two emperors of the Tang family are said to have died from partaking of the elixir. This circumstance diminished its popularity, and alchemy ceased to be practiced in the Celestial Empire.

At the beginning of the seventh century the doctrine of Lao-tse was in great favor at the Chinese court; learning was encouraged, and there was much enterprise. At the same time the disciples of Mohammed carried their arms and his doctrines over a large portion of Asia, and even to the Flowery Land. Throughout the eighth century there were frequent embassies between eastern and western Asia, wars with the caliphs, and even a matrimonial alliance. We need not wonder, therefore, that the teachings of the Taouist alchemists penetrated westward to the Arabian philosophers. It was at this period that Yeber-Abou-Moussah-Djaferal-Sofé, commonly called Geber, a Sabæan of great knowledge, started what to the West was a new philosophy about the transmutation of metals, the Philosopher's Stone, and the Elixir of Life; and this teaching was couched in highly poetic language, mixed with astrology, and accompanied by religious directions and rites. He held that all metals were composed of mercury, sulphur, and arsenic, in various proportions, and that the noblest metal could be procured only by a very lengthy purification. It was in the salts of gold and silver that he looked for the universal medicine. Geber himself was an experimental philosopher, and the belief in transmutation led to the acquirement of a considerable amount of chemical knowledge among the alchemists of Arabia and Europe.

This gradually brought about a conviction that the three reputed elementary bodies, mercury, sulphur, and salt, or acid, were not really the originators of all things. There was a transition period, during which the notion was itself suffering a transmutation. The idea became gradually clearer that all material bodies were made up of certain constituents, which could not be decomposed any further, and which, therefore, should be considered as elementary. The introduction of quantitative methods compelled the overthrow of mediæval chemistry, and led to the placing of the conception of simple and compound bodies upon the foundation of scientific fact. Lavoisier, perhaps, deserves the greatest credit in this matter, while the labors of the other great chemists of the eighteenth and the beginning of the nineteenth centuries were in a great measure directed to the analysis of every conceivable material, whether solid, liquid, or gaseous. These have resulted in the table of so-called elements, now nearly seventy in number, to which fresh additions are constantly being made.

Of this ever growing list of elements not one has been resolved into simpler bodies for three-quarters of a century; and we, who are removed by two or three generations from the great builders of our science, are tempted to look upon these bodies as though they were really simple forms of matter, not only unresolved, but unresolvable. The notation we employ favors this view and stamps it upon our minds.

Is it, however, a fact that these reputed elements are really simple bodies? or, indeed, are they widely different in the nature of their constitution from those bodies which we know to be chemical compounds? Thus, to take a particular instance, are fluorine, chlorine, bromine, and iodine essentially distinct in their nature from the compound halogens, cyanogen, sulphocyanogen, ferricyanogen, etc.? Are the metals lithium, sodium, and potassium essentially distinct from such alkaline bases as ammonium, ethylamine, diethylamine, etc.? No philosophical chemist would probably venture to answer this question categorically with either "yes" or "no." Let us endeavor to approach it from three different points of attack—(1) the evidence of the spectroscope, (2) certain peculiarities of the atomic weights, and (3) specific refraction.

1. *The Spectroscope.*—It was at first hoped that the spectroscope might throw much light upon the nature of elements, and might reveal a common constituent in two or more of them; thus, for instance, it was conceivable that the spectrum line of the bromine or iodine vapor might consist of the rays given by chlorine *plus* some others. All expectations of this have hitherto been disappointed; yet, on the other hand, it must not be supposed that such a re-

* Quoted from the translation by the Rev. Dr. Legge. In that most obscure classic, the "Yi-King," fire and water, wind and thunder, the ocean and the mountains, appear to be recognized as the elements.

† Students of the Apocrypha will remember the expression in the Book of Wisdom, xi. 17, "ἡ παντοδύναμός σου χεὶρ καὶ κτίσασα τὸν κόσμον ἐξ ἀμόρφου ὕλης" ("Thy Almighty hand, that made the world of matter without form"). The same book contains two allusions to the ordinary elements vii. 17, and xix 18 to 20. The word στοιχεῖον is used in the New Testament only in a general sense (2 Pet. iii. 10), or in its more popular meaning of the first steps in knowledge.

‡ Nearly all the statements relating to this Taouist alchemy are derived from the writings of the Rev. Joseph Edkins of Pekin, and the matter is treated in greater detail in an article on the "Birth of Alchemy," in the "Argonaut," vol. iii., p. 1.

sult disproves the compound nature of elements, for as investigation proceeds it becomes more and more clear that the spectrum of a compound is not made up of the spectra of its component parts.

Again, the multiplicity of rays given out by some elements, when heated, in a gaseous condition, such as iron, has been supposed to indicate more complex constitution than in the case of those metals, such as magnesium, which give a more simple spectrum. Yet it is perfectly conceivable that this may be due to a complexity of arrangement of atoms all of the same kind.

Again, we have changes of a spectrum at different temperatures; new rays appear, others disappear; or even there occurs the very remarkable change from a fluted spectrum to one of sharp lines at irregular intervals, or to certain recurring groups of lines This, in all probability, does arise from some redistribution, but it may be a redistribution in a molecular grouping of atoms of the same kind. and not a dissociation or rearrangement of dissimilar atoms.

A stronger argument has been derived from the revelations of the spectroscope in regard to the luminous atmospheres of the sun. There we can watch the effect of heat enormously transcending that of our hottest furnaces, and of movements compared with which our hurricanes and whirlwinds are the gentlest of zephyrs. Mr. Lockyer, in studying the prismatic spectra of the luminous prominences or spots of the sun, has frequently observed that on certain days certain lines, say of the iron spectrum, are non-existent, and on other days certain other lines disappear, and that in almost endless variety; and he has also remarked that occasionally certain lines of the iron spectrum will be crooked or displaced, thus showing the vapor to be in very rapid motion, while others are straight, and therefore comparatively at rest. Now, as a gas cannot be both at rest and in motion at the same time and the same place, it seems very clear that the two sets of lines must originate in two distinct layers of atmosphere, one above the other, and Mr. Lockyer's conclusion is that the iron molecule was dissociated by heat, and that its different constituents, on account of their different volatility, or some other cause, had floated away from one another. This seems to me the easiest explanation of the phenomenon; and, as dissociation by heat is a very common occurrence, there is no *a priori* improbability about it. But we are not shut up to it, for the different layers of atmosphere are certainly at different temperatures, and most probably of different composition. If they are of different temperatures, the variations of the spectrum may only be an extreme case of what must be acknowledged by every one more or less—that bodies emit or cease to emit different rays as their temperature increases, and notably when they pass from the liquid to the gaseous condition. And again, if the composition of the two layers of atmosphere be different, we have lately learnt how profoundly the admixture of a foreign substance will sometimes modify a luminous spectrum.

2. *Peculiarities of Atomic Weights.*—At the meeting of this Association at Ipswich, in 1851, M. Dumas showed that in several cases analogous elements form groups of three, the middle one of which has an atomic weight intermediate between those of the first and third, and that many of its physical and chemical properties are intermediate also. During the discussion upon his paper, and subsequently,* attention was drawn to the fact that this is not confined to groups of three, but that there exist many series of analogous elements having atomic weights which differ by certain increments, and that these increments are in most cases multiples of 8. Thus we have lithium, 7; sodium, 23, *i. e.*, $7 + 16$; potassium, 39, *i. e.*, $7 + (16 \times 2)$; and the more recently discovered rubidium, 85, *i. e.*, $7 + (16 \times 5)$ nearly; and cæsium, 133, *i. e.*, $7 + (16 \times 8)$ nearly. This is closely analogous to what we find in organic chemistry, where there are series of analogous bodies playing the part of metals, such as hydrogen, methyl, ethyl, etc., differing by an increment which has the atomic weight 14, and which we know to be CH_2. Again, there are elements with atomic weights nearly the same or nearly multiples of one another, instances of which are to be found in the great platinum group and the great cerium group. † This suggests the analogy of isomeric and polymeric bodies. There is also this remarkable circumstance: the various members of such a group as either of those just mentioned are found together at certain spots on the surface of the globe, and scarcely anywhere else. The chemist may be reminded of how in the dry distillation of some organic body he has obtained a mixture of polymerized hydrocarbons, and may perhaps be excused if he speculates whether in the process of formation of the platinum or the cerium group, however and whenever it took place, the different elements had been made from one another and imperfectly polymerized.

But this is not the largest generalization in regard to the peculiarities of these atomic weights. Newlands showed that by arranging the numbers in their order the octaves presented remarkable similarities, and, on the same principle, Mendeleff constructed his well known table. I may remind you that in this table the atomic weights are arranged in horizontal and vertical series, those in the vertical series differing from one another, as a rule, by the before mentioned multiples of 8—namely, 16, 16, 24, 24, 24, 24, 32, 32—the elements being generally analogous in their atomicity and in other chemical characters. Attached to the elements are figures, representing various physical properties, and these in the horizontal series appear as periodic functions of the atomic weights. The table is incomplete, especially in the lower portions, but, with all its imperfections and irregularities, there can be no doubt that it expresses a great truth of nature. Now, if we were to interpolate the compound bodies which act like elements—methyl, 15; ammonium, 18; cyanogen, 26—into Mendeleff's table, they would be utterly out of place, and would upset the order both of chemical analogy and of the periodicity of the physical properties.

3. *Specific Refraction.*—The specific refraction has been determined for a large majority of the elements, and is a very fundamental property, which belongs to them apparently in all their combinations, so long at least as the atomicity‡ is unchanged. If the figures representing this property be inserted into Mendeleff's table, we find that in the vertical columns the figures almost invariably decrease as the atomic weights increase. If, however, we look along the horizontal columns, or better still, if we plot the figures in the table by which Lothair Meyer has shown graphically that the molecular volume is a periodic function of the atomic weights, we shall see that they arrange themselves in a series of curves similar to but not at all coincident with his. The observations are not so complete or accurate as those of the molecular volumes, but they seem sufficient to establish the fact, while the points of the curves would appear to be, not the alkaline metals, as in Meyer's diagram, but hydrogen, phosphorus and sulphur, titanium and vanadium, selenium, antimony. Now, if we were to insert the specific refractions of cyanogen, ammonium, and methyl into this table, we should again show that it was an intrusion of strangers not in harmony with the family of elements.

But there is another argument to be derived from the action of light. The refraction equivalent of a compound body is the sum of the refraction equivalents of its compounds; and if there is anything known for certain in the whole subject, it is that the refraction equivalent of an organic compound advances by the same quantity (7·6) for every increment of CH_2. If, therefore, the increment between the different members of a group of analogous elements, such as the alkaline metals, be of the same character, we may expect to find that there is a regular increase of the refraction equivalent for each addition of 16. But this is utterly at variance with fact; thus, in the instance above quoted, the refraction equivalent of lithium being 3·8, that of sodium is 4·8, of potassium 8·1, of rubidium 14·0, and of cæsium about 13·7. Neither does the law obtain in those series in which the increment is not a multiple of 8, as in the case of the halogens, where the increment of atomic weight is 45, and the refraction equivalents are chlorine 9·9, bromine 15·3, and iodine 24·5.

The refraction equivalents of isomeric bodies are generally identical, and the refraction equivalents of polymeric bodies are in proportion to their atomic weights. Among the groups of analogous elements of the same, or nearly the same, atomic weight we do find certain analogies. Thus, cobalt and nickel are respectively 10·8 and 10·4, while iron and manganese are respectively 12·0 and 12·2. But, as far as observation has gone at present, we have reason to conclude that, if metals stand to one another in the ratio of 2:1 in atomic weight, their refraction equivalents are much nearer together than that; while on the other hand, the equivalent of sulphur, instead of being the double of that of oxygen, is at least five times as great.

The general tendency of these arguments is evidently to show that the elementary radicals are essentially different from the compound radicals, though their chemical functions are similar.

There remains still the hypothesis that there is a "primordial element," from which the others are derived by transmutation. With the sages of Asia it was the "blue ether," with Thales water, with Dr. Prout hydrogen. The earlier views have passed away, and the claims of hydrogen are being fought out on the battle field of atomic weights and their rigorous determination.

There does not appear to be any argument which is fatal to the idea that two or more of our supposed elements may differ from one another rather in form than in substance, or even that the whole seventy are only modifications of a prime element; but chemical analogies seem wanting. The closest analogy would be if we could prepare two allotropic conditions of some body, such as phosphorus or cyanogen, which should carry their allotropism into all their respective compounds, no compound of the one form being capable of change into a compound of the other. Our present knowledge of allotropism, and of variations in atomicity, affords little if any promise of this.

The remarkable relations between the atomic weights of the elements, and many peculiarities of their grouping, force upon us the conviction that they are not separate bodies created without reference to one another, but that they have been fashioned or built up from one another, according to some general plan. This plan we may hope gradually to understand better, but if we are ever to transform one of these supposed elements into another, or to split up one of them into two or three dissimilar forms of matter, it will probably be by the application of some method of analysis hitherto unknown.

Nothing can be of greater promise than the discovery of new methods of research; hence I need make no apology to others who have lately done excellent work in chemistry if I single out the Bakerian Lecture of this year, by Mr. Crookes, on "Radiant Matter Spectroscopy." It relates to the prismatic analysis, not of the light transmitted or absorbed in the ordinary way by a solid or liquid, nor of that given out by incandescent gas, but the analysis of the fluorescence that manifests itself in certain bodies when they are exposed to an electric discharge in a highly exhausted vacuum. He describes in an interesting and even amusing manner his three years' quest after the origin of a certain citron band, which he observed in the spectrum of the fluorescence of many substances, till he was led into that wonderful labyrinth of uncertain elements which are found together in samarskite, and eventually he proved the appearance to be due to yttrium. As the test is an extremely delicate one, he has obtained evidence of the very general dissemination of that element, in very minute quantities—and not always very minute—for the polypes that built up a certain pink coral were evidently able to separate the earth from the sea water, as their calcareous secretion contained about ½ per cent. of yttrium. We have reason to hope that this is only the first installment of discoveries to be made by this new method of research.

I cannot conclude without a reference to the brightening prospects of technical chemistry in this country. I do not allude to the progress of any particular industry, but to the increased facilities for the education of those engaged in the chemical manufactures. First as to the workpeople. Hitherto the young artisan has had little opportunity of learning at school what would be of the greatest service to him in his after career. The traditions of the Middle Ages were all in favor of literary culture for the upper classes, and the education suited for these has been retained in our schools for the sons of the people. It is true that some knowledge of common things has been given in the best schools, and the Education Department has lately encouraged the teaching of certain sciences in the upper standards. In the Mundella Code, however, which came into operation last year, "elementary science" may receive a grant in all the classes of a boys' or girls' school, and in the suggested scheme there is mentioned simple lessons on "the chemical and physical principles involved in one of the chief industries of England, among which agriculture may be reckoned," while "Chemistry" is inserted among "the specific subjects of instruction" that may be given to the older children. It is impossible, as yet, to form an estimate of the extent to which managers and teachers have availed themselves of this permission, for the examinations of Her Majesty's inspectors under the new code have only just commenced; but one of the best of the Board Schools in London has just passed satisfactorily in chemistry, both with boys and girls. I trust that in those parts of the country where chemical industries prevail, chemistry may be largely taken up in our elementary schools.

The great deficiency in our present educational arrangements is the want of the means of teaching a lad who has just left the common school the principles of that industry by which he is to earn his livelihood. The more purely scientific chemistry, however, may be learnt by him now in those evening classes which may be formed under the Education Department, as well as in those that have long been established under the Science and Art Department. The large amount of attention that is now being given to the subject of technical education is creating in our manufacturing centers many technical classes and colleges for students of older growth.

As to inventors and the owners of our chemical factories, in addition to the Chemical Society and the Chemical Institute, there has recently been founded the Society of Chemical Industry. It came into existence with much promise of success; at the close of its second year it numbered 1400 members; it has now powerful sections in London, Manchester, Liverpool, Newcastle, and Birmingham; and it diffuses information on technical subjects in a well-conducted monthly journal.

May the abstract science and its useful applications ever prove helpful to one another, and become more and more one Chemistry for the benefit of mankind!

* Phil. Mag., 1863.

† Another curious instance is the occurrence of nickel and cobalt in all meteoric irons, with occasionally chromium of manganese, the atomic weights and other properties of which are very similar.

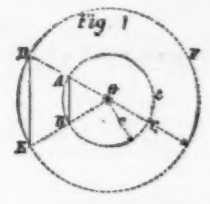
‡ This exception includes not merely such changes as that from a ferrous to a ferric salt, but the different ways in which the carbon is combined in such bodies as ethene, benzene, and pyrene.

THE EYE AS AN AID IN PHOTOMETRY.

THE important part fulfilled by the observer's eye in almost every method of photometrical measurement, has, probably, not escaped the notice of readers of the articles on photometry which have appeared in recent numbers of this journal. Even when photography is brought into use, as in MM. Fizeau and Foucalt's method, the eye has ultimately to determine the value of the different effects produced. It is only in such purely chemical methods as that of Bunsen and Roscoe that the eye does not play the part of a measure. It may, therefore, well be asked: How does light affect the eye, and within what limits can the eye judge differences of illumination?

Light is given off from every visible surface; being either reflected therefrom, transmitted through the substance of which it is a surface, or actually produced by molecular vibrations of the substance, as in the case of light from the surface of molten iron. A luminous point gives off rays of light in every direction, and those rays travel in straight lines. This is obvious, for from whatever position a luminous point is viewed, it is visible so long as no opaque object is interposed; but the rays do not travel by a curved line, and so pass round an obstacle.

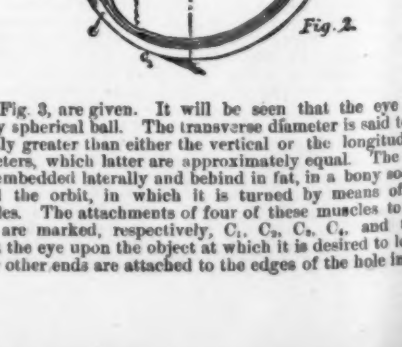
It will be obvious that a luminous point at the center of a hollow sphere will illuminate every equal portion of the internal surface of the sphere to an equal extent. Consequently the concave surface of the segment, A B, Fig. 1,



of a sphere, A B C, will receive from the luminous point, G, the same quantity of light as the concave surface, D E, of the sphere, D E F, and that quantity will, if the outer sphere be twice the size of the inner, be spread over an area four times as great; for the surface areas of spheres vary as the squares of the radii, the formula for ascertaining the area being $4 \pi r^2$; so if r equals 1, and r^1 equals 2, the surfaces would be as 1 to 4. Thus it is proved that the intensity of illumination of a surface is inversely as its distance from the source of light.

Considering this law, it is, at first, thought strange that objects should appear of almost exactly similar brightness at a considerable distance as when near at hand; but that they do appear similar is due to the fact that the areas of the images of such objects upon the retina likewise vary inversely as the squares of their distances from the observer; hence the physiological effect upon the portion of retina affected is similar, whatever the distance at which the objects may be from the observer. Any difference in the apparent brightness to an observer of two lights of similar size and brightness, but at different distances from him, is due to the absorption of light by the medium through which the rays of light pass from their sources to the observer.

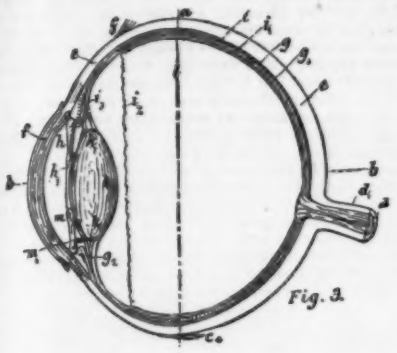
In order the better to explain the construction of the human eye, a vertical section, Fig. 2, and a horizontal sec-



tion, Fig. 3, are given. It will be seen that the eye is a nearly spherical ball. The transverse diameter is said to be slightly greater than either the vertical or the longitudinal diameters, which latter are approximately equal. The eye lies, embedded laterally and behind in fat, in a bony socket called the orbit, in which it is turned by means of six muscles. The attachments of four of these muscles to the balls are marked, respectively, C_1, C_2, C_3, C_4, and they direct the eye upon the object at which it is desired to look. Their other ends are attached to the edges of the hole in the

back of the orbit, through which hole the optic nerve, *d*, passes; its sheath, d_1, being a continuation of the outer coat of the eye. The other two muscles are attached rather to the rear of point, C_3, above and below it respectively. One pulls above, and the other below the eye, and they pull it forward toward the inner front part of the orbit.

The eye consists of a thick horny outer shell, the opaque portion of which, *e*, forms what is known as the white of the eye; it is called the sclerotica. The transparent portion,



f, similar in form to a watch glass, is called the cornea. It forms a segment of a smaller sphere than the eye, and is let into, and continuous with the sclerotica.

Immediately inside the sclerotica is the choroid coat, *g*, which consists of a close network of capillaries, joining numerous arteries and veins which lie outside the network, the whole being united by connective tissue layers of stellate cells, containing black pigment. The inner surface of the choroid coat is a single layer, g_1, of flattened hexagonal pigment cells, and, strictly speaking, forms part of the retina. The choroid coat is principally useful to absorb, by means of the black pigment, the rays of light which pass through the transparent retina. It ends, internally, in front, in a number of radii folds or ridges called ciliary processes, g_2. Externally, it is continuous with the iris, *h*, which is an annular opaque curtain, the inner diameter of which is variable, thus altering the size of the pupil, h_1, by which means the quantity of rays of light entering the eye is regulated.

The retina, a very delicate membrane, varying from the one one-hundred-and-sixtieth to the one-eightieth part of an inch in thickness, lies next inside the choroid coat. It is an expansion of the optic nerve, *d*, and is the only part of the eye which, under the influence of light, conveys the sensation of vision to the brain.

The outer portion of the retina, next the pigment cells, g_1, consists of a layer, *i*, of rods and cones, which are arranged radially, and by means of which the vibrations called light stimulate the fibers of the optic nerve. Inside the layer of rods and cones, which is barely one-sixth of the whole thickness of the retina, is a membrane, i_1, in which lie the nerve fibers from the optic nerve, and the blood vessels of the retina. The nervous elements of the retina end at the *ora serata*, i_2, a sort of wavy border line, beyond which only a delicate membrane of connective tissue, i_3, passes on to the crystalline lens, *k*.

From the choroid coat proceeds the elastic suspensory ligament, k_1, which supports the lens, *k*. The lens, too, is very elastic, especially in youth, but hardening with age; and when the eye is at rest, is kept in tension by the ligament, k_1. The front surface of the lens is then less convex than when the eye is adjusted for viewing near objects. The lens and its ligament divide the interior of the eye into two chambers, the larger of which, *l*, is filled with a delicate jelly called the vitreous humor. The smaller chamber is itself subdivided by the iris into the anterior and posterior aqueous chambers, *m* and m_1, respectively; so called because filled with watery fluid. These contents keep the eye in proper shape.

If, when the eye is fixed upon some object in front of the observer, a slight motion of any object takes place, even so far as 90° or 95° from the line of direct vision, the eye notices it, and an impulse is given to turn the eye and head in the direction of the moving object, to view it more directly. It will thus be seen that the eyes are conscious of movements occurring in fully, if not more than, a semicircle about the observer. That a ray of light coming from the moving object on one side should be bent from its straight course and pass through the pupil on to the retina, is due to the fact that although the ray moves in a straight line so long as it is passing through the same medium, part of the light is reflected from the surface at which the rest enters another medium, while that which enters the second medium moves through it at an angle to its original course in the first medium. This bending of the course of the ray is termed refraction. Whatever may be the angle at which a ray strikes a surface, the sine of the angle which it makes with the perpendicular to that surface, and the sine of the angle which it makes with the same perpendicular while passing through the second medium, are always in the same ratio. Taking a vacuum as the standard of comparison, we have:

$$\frac{\text{Sine of angle of incidence in vacuum}}{\text{Sine of angle of refraction in a medium}} =$$

A constant quantity, termed the index of refraction, for that medium.

The bending that takes place when a ray passes from a vacuum into the air or gases is very slight; on entering water, or the media of the eye, it is much more, and on entering glass still more. The following are some of the indices of refraction:

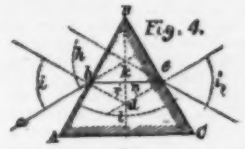
Hydrogen	1·000138
Air	1·000294
Chlorine	1·000772
Pure water	1·336
Alcohol	1·372
The aqueous humor of the eye	1·3366
" vitreous " "	1·339
" cornea	1·377
" outer coat of crystalline lens	1·337
" inner " "	1·379
" central portion "	1·399
Crown glass, average "	1·547
Flint " "	1·609

The same law of sines holds good between any two media, and the relative index of refraction for those media is the ratio of their indices with respect to a vacuum. Thus

from air to water the relative index $= \frac{1{\cdot}336}{1{\cdot}000294} = 1{\cdot}335607$.

Hence the bending is almost as great from air as from a vacuum. On leaving the medium in which refraction has occurred, and returning into the medium through which it was previously passing, the ray resumes a course parallel to its original course, if the surfaces at which it enters and leaves the intermediate medium are parallel. If those surfaces are not parallel, there is a permanent bending of the ray. The differences of the refractive indices of the various media of the eye are very small; consequently, the bending, after the ray has once entered the cornea, is slight. A ray, bending from its path through the air on entering the cornea, would on leaving the cornea return slightly toward its original course; but in passing through the lens it would be bent further from that course, again returning slightly to it on entering the vitreous humor. Although the refractive index of glass is greater than those of the media through which light passes in the eye, a ray being bent more on entering glass than on entering the eye, yet much may be learnt concerning the eye from experiments with glass prisms and lenses, for it is to refraction that the phenomena produced by them are due.

If *a b*, Fig. 4, be a ray falling upon the surface, A B, of



the prism, A B C, and in the plane of a principal section of the prism, and if *i* be the angle of incidence, and *r* the refracted angle, μ being the relative index of refraction; then sin. $i = \mu$ sin. *r*. Similarly on leaving the surface, B C, the ray takes a course, *e g*, and here sin. $i_1 = \mu$ sin. r_1. The deviation produced at *b* is $i - r$, and at *e* it is $i_1 - r_1$. The total deviation is the angle, *h*, consequently

$$h = i_1 - r + i - r_1 \quad . \quad . \quad . \quad (1)$$

A perpendicular let fall from B upon the point of intersection of the rays at *k* divides the angle, *l*, into two parts, of which A B $k = r$ and C B $k = r_1$; for B *b* is perpendicular to *b d*, and B *k* is also perpendicular to *b e*, and the angle contained by the perpendiculars to two lines is equal to the angle contained by the lines themselves. Consequently the angle $l = r + r_1$, which value being substituted in equation (1) gives:

$$h = i + i_1 - (r + r_1) = i + i_1 - l \quad . \quad . \quad . \quad (2)$$

When the ray, *b e*, through the prism makes the angles at the two surfaces, *b* and *e*, equal, the angles, *r* and r_1, with the perpendiculars to those surfaces must be equal, and consequently $i = i_1$, for μ is of the same value in both cases. Thus equation (2) becomes $h = i + i_1 - l = 2i - l$, whence

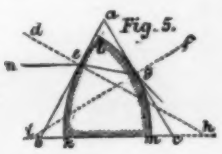
$$i = \frac{h + l}{2} \quad . \quad . \quad . \quad (3)$$

Moreover

$$\mu = \frac{\text{sin. } i}{\text{sin. } r} = \frac{\text{Sin.} \frac{h + l}{2}}{\text{sin.} \frac{h}{2}} \quad . \quad . \quad . \quad (4)$$

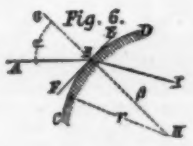
Thus the index of refraction is obtainable by calculation from measurement of the angle, *l*, of the prism, and the angle, *h*, of total deviation.

Again, if *a b c*, Fig. 5, represent the section of a prism,

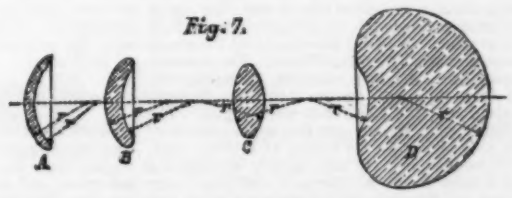


and if the perpendiculars, *d e*, *f g*, to the faces, *a b*, *a c*, be continued to cut a line continued from the base, *b c*, at *h* and *i*, and if arcs, *k e l*, *m g l*, be struck from *h* and *i*, then the path of a ray, *n e g o*, would not be altered. Hence it will be obvious that with curved surfaces a tangent must be drawn at the point of incidence of the ray, and that the angles of coincidence and refraction must be taken from perpendiculars to the tangents drawn from the points of incidence and exit respectively. Thus, if the ray, A B, Fig. 6, is incident at B upon the curved surface, C D, and if E F is the tangent at B, and G H the perpendicular thereto, then $\frac{\text{sin } \alpha}{\mu} = \text{sin. } \beta$, which gives the direction of B I, the refracted ray.

These remarks will make plain the action of lenses in



causing refraction, for a lens may be regarded as the revolution of a figure similar to *k e l g m*, Fig. 5, about an axis, *k m*. Such a lens is called a double convex lens, and the crystalline lens of the eye belongs to that class. But in the eye there are lenses of other forms. First, the cornea, A, Fig. 7, which is of the class called a converging meniscus; then the aqueous humor, B, which is practically a lens of similar class but of different refractive power; next there is the crystalline lens, C, and finally the vitreous humor, D, which is practically a very thick diverging meniscus. These four lenses, when built up into one compound lens, have a similar effect to that a globular lens would have if made of materials of sufficiently high refractive index, to focus parallel rays at twice the radius of curvature, viz., at the opposite surface to that at which the rays enter. The mean refractive index of the various



media of the eye is, however, but little more than that of water, and this has to be compensated for in order that the rays may be focused upon the retina, which fits closely on the outer surface of the lens, D, Fig. 7. This compensation is effected by the projection of the cornea beyond the surface of the larger sphere, and by its surface having a smaller radius of curvature.

(To be continued.)

ON THE INDURATED SHALES BETWEEN BERGEN HILL AND THE PALISADES, N. J.*

By NELSON H. DARTON.

THE peculiar topography of the district at the juncture of Bergen Hill and the Palisades near Weehawken, New Jersey, cannot fail to attract the attention of those who have passed through it; a picturesque ravine commencing at that point and running north for some distance, and the fine headland of King's Point being remarkable features in the scenery, and at once impressing the observer with the fact that there must be a break in the continuity of the trap ridges here so prominently exposed, and this occupied by other and softer strata. This has recently been found by the author to be the case, and as it affords an interesting detail in our local geology, I will give an account of the arrangement of these strata.

As is well known, Bergen Hill trends sharply to the east a short distance north of Hoboken, and after nearly reaching the Hudson River again follows a northern direction, forming the Palisades, which commence here at King's Point. Some distance north of this they have been pierced by the tunnel for the New York, West Shore & Buffalo R. R., and at no other point for some miles can a section of the hill be found exposed to view. And it was in this tunnel that the shales which form the subject of this notice were first met with. Having noticed them while the tunnel was being excavated, I at once saw the extreme probability of their being continuous south to, and their underlying King's Ravine, which is a deep depression, as its name implies, and runs behind the Palisades for some distance north, as before noticed.

The strata of shales crossed the tunnel nearly at right angles and have a thickness of about a hundred feet. They are highly indurated, of very dark color, often purple, and distinctly stratified, while the bedding was generally very regular; in places it was much disturbed and filled with fissures of calcite. The dip was N. 20° W. >60° on an average of several closely agreeing determinations. These strata are five hundred feet from the eastern entrance to the tunnel, and between shafts Nos. 1 and 2. This portion is now walled from view by the brick arching necessary at this point; but fortunately there is a manhole in the south wall where the strata are finely exposed, and also in the floor of the tunnel under the ballasting and ties.

Directly above this, on the surface, is a depression now nearly filled with the peat beds of a morass and a brook, but whose surface is now about twenty-five to thirty feet below the otherwise level surface of the hill. This depression was found to be continuous for about a mile north of the tunnel, and its depth, width, and direction singularly sharply defined and unbroken until abruptly terminated by a hill near the Bull's Ferry road. The outcrops of trap on either side, and forming the abrupt walls of the depression, are constantly exposed and are parallel both to each other and the edge of the Palisades, about five hundred feet to the east, while the height is quite uniformly one hundred and fifty feet.

South from the tunnel the depression, although not so well defined as to the north, was, nevertheless, found to be continuous to the head of King's Ravine, where it broadens to twice its former width, and bifurcates around a tongue of trap rock, the west branch forming the slope for the Hackensack Turnpike, which runs between this tongue of trap, in one place over thirty feet in height, and Bergen Hill, which at the bottom of the slope is over a hundred feet high, and where it is seen to lie upon the arkose of the "One Hundred Steps," which underlies it for some distance up the slope, and near its end is pierced by two dikes of trap, one ten and the other twenty-five feet in width, which form a connection between the trap of the hill above and another sheet below, which I will presently describe. The arkose has a dip N. 20° W. > 20°. Across the turnpike and opposite to this locality the tongue of trap has sunk beneath the surface rather abruptly, but again appears in two small outcrops a short distance south near the Porter's Lodge on the road of the Kings' property. This sheet of trap is that before referred to as lying beneath the arkose, and from which the dikes ascend. The arkose is thus found to be but thirty feet in thickness, and this trap sheet, which separates it from King's Ravine, from about two hundred feet to forty in thickness.

The eastern branch of the bifurcation of the depression previously described is King's Ravine. This deep valley is walled on the east by the high precipitous walk of the inside of the Palisades, and on the east by the tongue of trap, or as it might be termed the intermediate schist, which has also precipitous sides. The ravine slopes rapidly downward, keeping below the level of the turnpike and traversed by the brook. It broadens out where the intermediate trap schist sinks beneath the surface, and being then unseparated from the turnpike, forms with it a valley sloping down to the Hoboken meadows at the lumber docks of the Erie Railroad. The ravine is in a direct line with the strata exposed in the tunnel, and I had considered it to be underlaid by these shales, although I had never noticed any outcrop in either the ravine or the depressions. In conversation, however, with a Mr. Atwood, an engineer of the West Shore road, I learned that while selecting a place for the tunnel and examining King's Ravine, he had incidentally noticed a small outcrop of a peculiar rock, which he thought might be an indurated shale. Some time after, again visiting the ravine, I found this outcrop in the bushes and shrubbery,

* Read before the New York Academy of Sciences, October 15, 1883.

and although small in extent or elevation it was unmistakably in place. A few feet to the south is a well, a hundred and forty feet in depth, for supplying the water for Mr. Gracie King's house on the bluff, and from the pit from which the bore was started much rock was thrown out, which lies in the piles of rubbish near by, and which I found was also indurated shale; besides which it is pierced by the well until that strikes the trap on which the strata lie, and probably the source of the water for the well. The strata are distinctly stratified and dip about N. 10° W. >40°. Carefully collected samples of this outcrop and of that in the tunnel were analyzed with the following results, to which are added some analyses of characteristic indurated shales from other portions of the State, and are taken from "The Geology of New Jersey."

Number one being from Lochatong Creek, near Milltown, in Hunterdon County.

Number two from farm of Spencer S. Wearts, near Hopewell, Mercer County; and

Number three from Moore's Mills, southwest of Hopewell, on Stony Brook, in Mercer County.

	In Tunnel.	In Ravine.	No. 1.	No. 2.	No. 3.
S_iO_2 ...	57·28	55·95	51·02	51·2	58·60
Fe_2O_3...	9·53	12·86	9·42	8·1	5·89
Al_2O_3 ..	26·14	23·46	22·45	20·2	20·66
CaO ...	2·01	Trace.	2·63	3·8	4·79
MgO	....	3 81	3·37	5·4	0·65
N_2O ..	0·42	0·28	2·18	....	6 48
K_2O ..	0 32	0 61	1·38	....	1·44
MnO ..	1 27	2·31	0 93	0·1	....
H_2O, etc	2·41	0·44	2·54	1·7	0·65
SO_3	0 21	0·04	2·81		....
CO_2 .	0·20	Nil.	1·30	5·6	0·80
	99·79	99·76	99·98	....	99·98

These analyses show a great similarity in the composition of the strata, and that they are similar to the indurated shales from other portions of the State It is extremely probable that they are continuous from Bull's Ferry road to the south end of King's Ravine, and perhaps even further. Evidences of eroding agents are very plentiful on the Ravine, as its sides are scored with water marks and diluvial scratches in great number, accounting for the removal of this softer material, which once filled it level with the trap on either side.

At the extreme southeastern corner of the ravine, and low down by the bed of the brook near the fence, forming the southern boundary of King's property, is a small outcrop of a finer grained arkose. This is part of those which are seen under the Palisades.

The alternation of the strata, as thus determined, are as follows from the east: First, the fine grained arkose under the Palisades, then the Palisades, then the indurated shales under the ravine, then the intermediate trap sheet, and then the arkose under Bergen Hill, and upon which lies the Hackensack turnpike; finally, Bergen Hill, connected with the intermediate trap sheet by the two dikes.

N. Y. Laboratory, 112 Water Street.

THE DUTCH FLYING ZOOLOGICAL STATION.

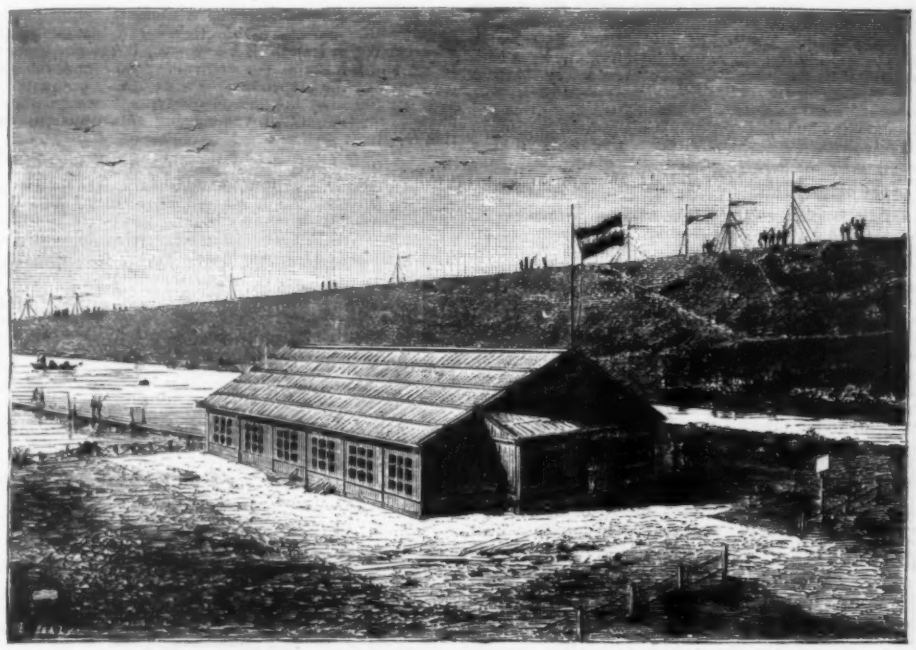
ZOOLOGICAL science has, for a few years past, been pursuing a path leading to brilliant discoveries. An examination, however minute it be, of animals preserved in collections is now no longer sufficient for the naturalist, for he needs to study the living world, since without this he can obtain no accurate ideas in regard to the affinities by which species are connected. Zoology has became experimental; maritime stations have been established on all sides, and numerous laborers in anatomy and embryology have thrown a brilliant light upon the philosophical theory of the transformation of beings, by showing that metamorphoses which were almost unknown a half century ago, are very common among marine animals. Holland, which has produced so great anatomists and so patient naturalists, was apparently remaining behind in the movement being made by neighboring nations, when, on the 4th of December, 1875, the Zoological Society, upon a proposition of Professor Hoffman, its president, voted the creation of a zoological station upon the shores of the North Sea. A commission, consisting of Messrs. Hoffman, Hubrecht, and Hœk, immediately entered upon a study of the project, and decided upon the creation of a station that should be easily transferred from one point to another on the coast of the Netherlands. With its sandy but slightly sloping beaches, Holland possesses, in fact, only a relatively poor zoological fauna. The commission rightly thought, then, that a "flying" station would render more services than a permanent one, by permitting of a successive exploration of the different parts of the seashore.

The appeal made by the Netherlands Society to the generosity of the State, of learned societies, and of private individuals was listened to, and, a sum of 10,000 francs having been quickly collected, work was at once begun. For the first campaign the city of Helder was chosen, this being situated at the southern extremity of the province of New Holland, at a point where an arm of the sea, called Helsdeur, separates the mainland from the isle of Texel. The *materiel*, loaded on a wagon drawn by oxen, reached its destination on the 8th of July, 1876, and on the following day the station was in place, and the researches were begun. The sea bottom at Helder is, as throughout the whole extent of the Netherlands coast, composed of masses of shifting sand, and, under such circumstances, it can scarcely be expected that those fixed animal forms will be met with that rocky bottoms are so rich in. Few species can resist the sand, that covers and smothers them. But, while dunes extend to the west of Helder, there rises to the north a dike of granite and basalt, which forms an artificial rock in whose sinuosities numerous animals can take shelter; and this is the only point on the Dutch coast where laminarians are found. The Minister of the Marine having consented to put a steam launch at the disposal of the commission twice a week, it has been rendered possible to employ Wyville Thompson's small drags, and Lacaze Duthiers' apparatus, and to collect as many as 130 species of invertebrates. The second year the station was established at Vlissingen, and the coast here has shown itself no less rich in animal forms than the Nieuvediep beach and the Helder dike. The following years the station was transferred to Bergen-op-Zoom.

In recent times the commission has not applied itself solely to an examination of the animals that live on the coast of Holland, however interesting such a study may be, but has made it the object of its researches to furnish oyster culturists with as complete information as possible in regard to the anatomy and embryology, the enemies and diseases, in a word, in regard to the biology of the oyster. The reason of this is that the East Scheldt has now become an important center of oyster farming, and to such a degree that the two stations, Kruiningen in Zeeland and Bergen-op-Zoom in North Brabant exported in 1881 about two millions of oysters of a value of nearly three million francs.

In order that the station may be as quickly established on various points of the coast as we have said, it is necessary that the building shall be capable of being easily taken apart and put in place again. The station is, in fact, entirely constructed of wood, and the different pieces are arranged with such care that the house can be taken apart and put together again in three days.

The station which we have just been able to visit at Bergen-op-Zoom, and the honors of which have been done us by Professor Hubrecht with that extreme complaisance and that perfect urbanity that distinguishes Dutch savants, consists of a principal building, eight meters in length by five in width, having four windows on one side and three on the other. The walls are three meters in height. The framework of the roof is of wood, covered with a double layer of rush mats, and its ridge rises to 4·5 m. There is a table fixed opposite each window, and others are arranged in the center of the room. In the laboratory there is a closet for instruments, one for reagents and bottles, and a small library containing a few periodicals and the principal works on marine fauna. Each maker can, moreover, have what books he needs sent him from the library of the Zoological Society or from one of the Dutch universities. A desk, some stools, and a few flexible iron chairs complete the furniture. The workroom, properly so called, is entered through a room that contains the aquaria, the fishing apparatus, and the small dragnets. The large instruments are placed in a chamber adjoining one of the sides of the main building. Another room, adjoining the part opposite the door, serves as a private office for the director of the station. An inclosure of galvanized zinc wire runs around the building, and, while keeping intruders to a distance, incloses a space which may be utilized either for open air experiments or for the dissection of animals of large size.



THE DUTCH FLYING ZOOLOGICAL STATION.

The construction of the wooden building, as it now stands, cost 5,700 francs. The additional sum of 6,000 francs was expended in the purchase of furniture, aquaria, fishing apparatus, reagents, thermometers, etc.

The working of the station has been regulated in the simplest manner. The members of the Zoological Society name, every year, a committee which publishes at the end of the year a narrative of the work done, and renders an account of the funds used.

Although the means for operating at the disposal of the commission are of the most limited nature, its members have nevertheless undertaken important labors. During the campaign at Helder, Mr. Hubrecht devoted himself to fishes, Mr. Hœk studied the crustaceans, Mr. Horst the annelides, and Messrs. Van Harem, Noman, and Sluiter divided between them the other invertebrates. Mr. Hœk undertook, at Bergen-op-Zoom, his interesting researches upon the embryology of the edible oyster.—*H. E. Sauvage, in La Nature.*

THE PHYSIOLOGICAL STATION AT PARIS.

SINCE securing the development of primary instruction, our government has been bestowing its attention upon higher education in its turn, and has been encouraging scientists, and furnishing them with the means of multiplying their discoveries in order to increase the glory, strength, and wealth of the country. In fact scientific questions are intimately connected with economic problems, or, more correctly speaking, they subordinate them. A people anxious to hold its rank must bring still more solicitude to the proper utilization of its intellectual powers than to the organization of its work and its industries, for progress of a material kind is very quickly arrested if science does not continually open up new routes for it.

During recent years we have observed the creation everywhere of establishments in harmony with the new needs of science. Laboratories, however, notwithstanding the great discoveries that have been made therein, have become inadequate in certain respects; for, in the study of organized bodies, as well as in that of the physical forces of the globe, we should soon come to a standstill could we not go out to observe nature in her own domain.

The necessity for special establishments made itself felt of itself, with certain sciences, with meteorology for instance. Later on, naturalists in their turn have felt the inadequacy of the means placed at their disposal. Maritime stations and gardens of acclimation, experimental grounds, agricultural stations, stations for the study of vegetable chemistry and experimental medicine. All these new creations are responding to new developments in certain branches of science.

Physiology, almost alone, has up to the present time been confined to its laboratories, which in France at least, are cheerless, poverty stricken, and unhealthy places, wherein investigators are condemned to live in the sole hope of discovering the properties of the tissues and the functions of the living organs. It is here that is determined the action of medicines upon the living organism, and that of poisons and of the different chemical and physical agents; and it is here, too, that, by means of vivisections or the use of delicate and accurate instruments, is analyzed the intimate mechanism of the functions of life.

Such a state of things could not long be kept up. It is clear that, with the limited means at its disposal, and confined within narrow spaces and reduced to operations upon a few of the lower animals, physiology would soon have fallen behind the other sciences. At all events, it would have had to give up hope of reaching its complete development, and would have left the ideas that it had acquired at the cost of so much effort without practical application. Let us cite one example among many others. Physiologists have, during the last half century, made numerous investigations on the nervous and muscular systems. We have learned how to distinguish the nerves of sensitiveness and motion, and how to determine the passage of these two sorts of nerves through the different parts of the body. We know how excitations act upon these organs, according to their intensity or nature; we have measured the velocity with which that as yet mysterious agent, that carries to the muscles the orders to move, makes its way through the nerves and spinal marrow; we have decomposed the action of the muscles themselves into its final elements—species of undulatory vibrations that make their way along the muscular fiber, and, finally, we have studied the nature of contractions, and know how fatigue, heat, cold, poisons, etc., modify the characters of these motions. On another hand, on taking up the subject of the mechanical conditions of animal locomotion, we have, from a kinematic point of view, determined the characters of the different motions in man and the lower animals; we have classified, according to their genera, the different osseous levers of the skeleton, determined the centers and the radii of curvature of the articulations, and calculated the momentum of those antagonistic forces which represent the power and resistance in the animal machine.

It would seem, then, as if everything were ready, and that physiologists had nothing more to do but make an application of these studies to the different problems of practical life. They are going to teach us, doubtless, how to utilize to the best possible degree the muscular work of man and the domestic animals, and they will fix the rules that should preside over the physical exercises of young people, over the professional labors of workmen, and over the maneuvers of soldiers.

Unfortunately this is not so. In the narrow conditions in which they are placed, physiologists have scarcely been able to study the functions of life in man or in the large animal species; and, besides, their ordinary method—that of vivisection—which has brought out so many discoveries regarding the properties of the tissues and the functions of isolated organs, cannot serve for ascertaining the regular operation of normal life.

The author of this article has spent long years in seeking methods and apparatus that should be capable of faithfully translating the external signs of life's functions. The pulsations of the heart and arteries, respiratory motions and contractions of the muscles, inscribe themselves automatically with these apparatus, and produce, for analysis, curves wherein are shown the least details in motion. Other instruments, still, are designed for inscribing the space traversed by a man or lower animal, or the stresses developed as a function of the time, etc. More recently, instantaneous photography has come to complete our knowledge of physiological motions, so that we can now easily solve the majority of the problems concerning animal mechanics.

But, notwithstanding that methods had been improved and new apparatus created, all the difficulties had not as yet been overcome, since it is not in the ordinary laboratory of physiology that we can study the motions of a bird upon the wing, a horse running at full speed, or even those of a man

who is walking, running, or indulging in some other muscular exercise. It is in view of such researches on the physiology of man and the lower animals that has been created the physiological station that we are to describe.

The Municipal Council of Paris was alone capable of disposing of the ground adequate for these sorts of experiments. A very suitable space existed upon Avenue des Princes, near La Pate d'Auteuil. With that generosity that is characteristic of it when scientific questions are concerned, the Council accorded the use of these grounds, and even voted a subsidy to cover a part of the cost of the experiments. On another hand, Mr. Jules Ferry, Minister of Public Instruction, pleaded warmly before the Chambers in favor of the projected establishment. The sum designed for constructing the requisite buildings was accorded by a law of August, 1882. The work was pushed forward with activity

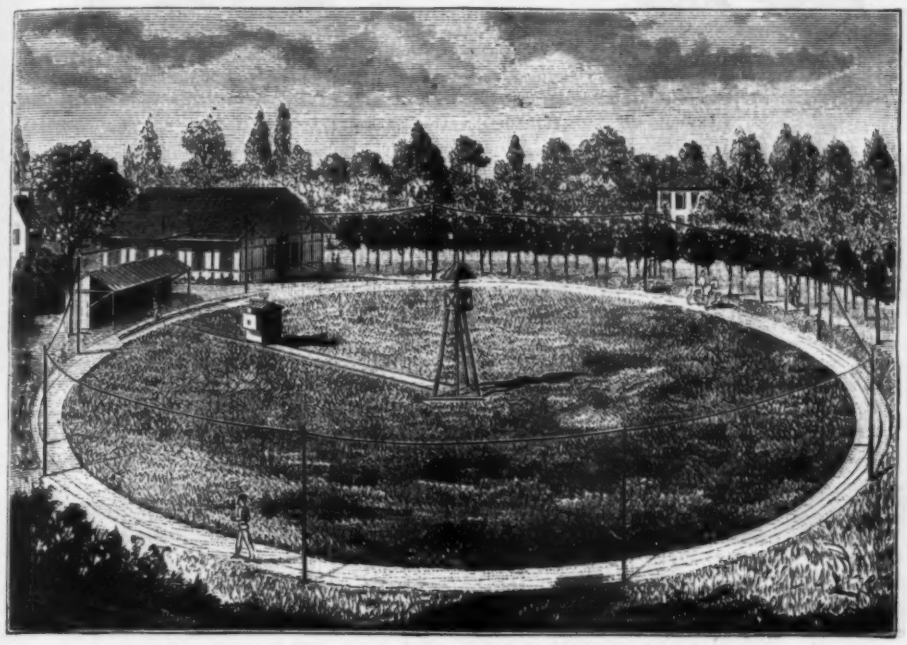


FIG. 1.—GENERAL VIEW OF THE PHYSIOLOGICAL STATION.

during last autumn and winter, so that, in the month of March, it was possible to begin experiments at the new station.

The number of practical applications of physiology is infinite; and, in this vast whole, there are certain questions whose solution is imminent, and certain others for which nothing is as yet prepared.

While future needs have been foreseen, the Station is at present arranged for the study of animal mechanics, and the experiments now being performed are connected with human locomotion.

The questions that present themselves in the first place are the following: (1) to determine the series of acts that occur in human locomotion, with its different types, such as walking, running, and jumping; (2) to find out the external conditions that modify such acts, those for example that increase the speed of the gait or the length of the step, and that

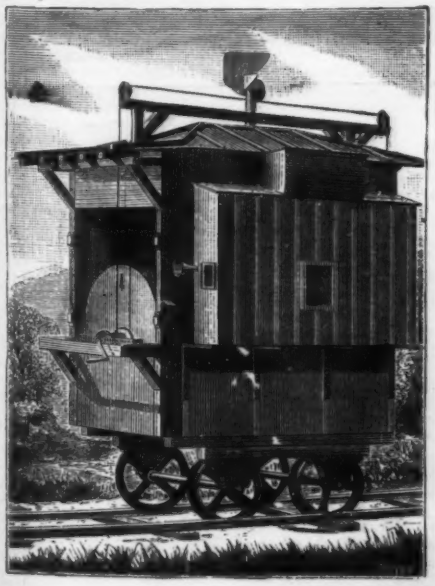


FIG. 2.—DARK CHAMBER ON WHEELS.

thus exert a favorable or an unfavorable influence upon man's locomotion; and (3) to measure the power expended at each instant in the different acts of locomotion in order to find out the most favorable conditions for the proper utilization of such power.

Instantaneous photography and different other applications of the graphic method serve to solve such questions as these, which are all inaccessible to direct observation.

Before entering into a detail of the experiments we shall point out the general arrangement of the Station. Fig. 1 gives a general view of the grounds and buildings.

On these grounds, which were laid out by the city of Paris as a nursery, there is a circular road 4 meters in diameter designed for the exercises of horses, and, external to this, a footpath for men. All around this road there runs a telegraph line, whose poles are spaced 50 meters apart. Every time that a person walks in front of a pole a telegraphic signal is given, and this is inscribed in one of the rooms of the principal building. We shall speak further on of this sort of automatic inscription, by means of which we ascertain at every instant the speed of the walker, his variations therein, and even the frequency of his steps. In the center of the track there is a high post that carries a mechanical drum which regulates the rhythm of the gait, and which is actuated by a special telegraph line running from one of the rooms in the large building, wherein the rhythm is regulated by a mechanical interrupter.

From the center of the circle likewise there starts a small railway upon which runs a car that forms a photographic chamber, from the interior of which is taken a series of instantaneous images of the horses or men whose gait we desire to analyze. These photographs are taken when the walker is passing before a dark screen which has already been described in this journal. Finally, the dynamographic studies that are designed to measure the power expended in different muscular acts are effected by means of apparatus that will be described hereafter.

1. *Instantaneous Photographs.*—The readers of this journal already know in detail the history of the applications of instantaneous photography in the analysis of the locomotion of man and the lower animals; they saw, at the time they made their appearance, the beautiful images obtained by Mr. Muybridge, who has succeeded in photographing the race-horse going at full speed; and finally, they know how we, for the physiological analysis of motion, have substituted for Mr. Muybridge's multiple apparatus a single one that gives upon the same plate the successive positions of a man or animal at the different instants that he is passing in front of a black screen. We

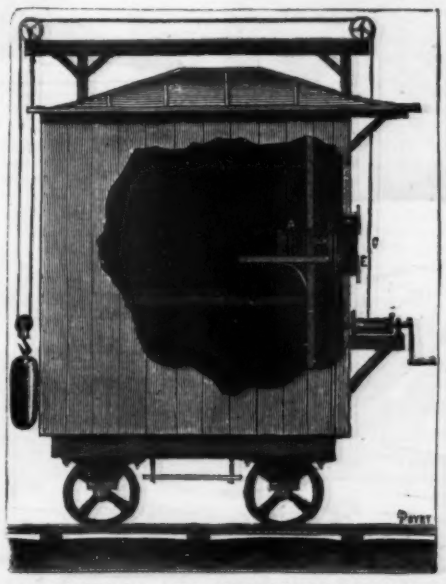


FIG. 3.—INTERIOR ARRANGEMENT OF THE DARK CHAMBER.

shall, however, have to revert to these experiments in order to make known certain new improvements which render the figures sharper and the measurement of the time more accurate, and which, multiplying the number of images almost indefinitely, give a complete analysis of every kind of motion.

The arrangement adopted at the Station for instantaneously photographing motions comprehends two distinct parts; on the one hand, a photographic apparatus with the rolling chamber that contains it, and, on the other, the black screen upon which detach themselves, in white, the men or animals whose images are being taken, as well as the instruments designed for measuring the spaces traversed between two successive images, and the time taken to traverse them.

Fig. 2 represents the photographic chamber in which the experimenter places himself. This chamber is mounted upon wheels, and runs upon a railway in such a way that it can approach or move away from the screen according to the objectives that are being used and to the size of the images that it is desired to obtain. As a general thing, it is advantageous to place the photographic apparatus quite far from the screen, say at about 40 meters. From this distance the angle at which the subject whose image is being taken presents itself does not change much during the time he takes to pass before the black screen. From the exterior of this chamber are seen the red windows through which the operator can follow the different motions that he is studying. He gives his orders to have the different acts performed through a speaking trumpet. The front of the chamber is removed in Fig. 2 in order to show a revolving disk provided with a small window through which the light enters the photographic objective intermittently. This disk is of large dimensions (1·5 m. in diameter), and the window in it represents only a hundredth of its circumference. It follows from this that if the disk makes ten revolutions per second, the duration of lighting will be but *one thousandth of a second.* Motion is communicated to the disk by a train of wheels which is wound up with a winch and which is actuated by a 150 kilogramme weight placed behind the chamber. The motion of the disk is arrested by a brake, and a bell maneuvered from the interior serves to give orders to an aid either to set the disk in operation or to stop it.

Fig. 3 shows the inner arrangement of the chamber, a portion of one of the sides being removed to show the photographic apparatus, A, placed upon a bracket before the screen. This apparatus receives long and narrow sensitized plates that exactly hold an entire image of the screen. The plates that have given us the best results are those of Van Monckhoven of Gand, and those of Melazzo of Naples. At B is the revolving disk which produces the intermittent illuminations, and at D is a cut-off which is raised vertically at the beginning of the experiment, and which is allowed to fall at the end so as to allow light to enter only during the time that is strictly necessary. E is a wide slit in front of the objective for allowing the latter to take in the field in which are occurring the motions that are being studied.

The darkness that reigns in the rolling chamber permits of manipulating the sensitized plates therein at ease, and of changing them at every new experiment.—*E. J. Marey, in La Nature.*

THE STRONTIA PROCESS OF EXTRACTING SUGAR FROM BEETROOT MOLASSES.

A CORRESPONDENT writes: "The increase in the consumption of sugar in the United Kingdom during the last ten years is immense. In 1843, it was about 200,000 tons. In 1854 it was doubled, being equal to 400,000 tons. In 1874 it amounted to 850,000 tons, and in 1882 to 1,000,000 tons. Of these quantities, in 1870 165,000 tons were beetroot sugar, and in 1882 over 400,000 tons beetroot sugar, the whole of which was imported from Germany, Holland, Belgium, and France. The value of the beetroot sugar imported into England is now about £10,000,000 per annum. The manufacture of beetroot sugar is entirely neglected in this country, although it has been proved that sugar beets can be grown to advantage. When the cultivation of the sugar beet first assumed importance on the Continent (about 1850), an official inquiry was ordered by the then Lord Lieutenant of Ireland, Lord Clarendon, and the report was presented to Parliament in 1852. A series of trials were made in different parts of Ireland with sugar beets, the results of which may be summed up as follows: 78 per cent. of the beets grown in Ireland, 75 per cent. of those grown in England, and 70 per cent. of those grown in Belgium were rich enough to be worked. Notwithstanding this favorable report, nothing was done, as no capitalists took up the idea. The West Indian sugar had then the command of the market, and those engaged in the trade saw no necessity for a change. Since then the sugar trade has been revolutionized. The Continental growers have improved the sugar beet, and, assisted by Government bounties, have ruined many of our largest refineries. An economical process has recently been discovered in Germany for the recovery of sugar from beetroot molasses, or any solution of sugar, by the use of strontia, which is the alkaline earth of which strontium is the metallic basis. The process was secretly worked in Germany for some years until recently, when patents were taken out for its working by Dr. Scheibler, Professor of Chemistry at the Royal Agricultural College, Berlin, and chemist of the Beetroot Sugar Institution. By the use of this process very large profits are now being made in Germany, and refineries in different parts of the Continent (notably France and Russia) are adopting the process rapidly. A large deposit of strontia has been proved to exist in this country. By the new process referred to, the prospect of beetroot cultivation and the manufacture of sugar therefrom in the United Kingdom is greatly enhanced. To produce one ton of beetroot sugar one acre of land is required. The imports are 400,000 tons of beetroot sugar per annum. The crop of sugar beet can be taken every three years. If, therefore, 1,200,000 acres of suitable land could be brought under beet cultivation, the whole of the beetroot sugar consumed in the country could be produced at home. A large proportion, if not the whole of this land, could be obtained in Ireland. The advantages which may accrue to Ireland from the establishment of the manufacture of sugar from beetroot, appears to be not only that it will create a new and extensive source of manufacturing employment, but that, as the material used can only be profitably obtained by means of improved agriculture, the manufactories of beet sugar should exercise a powerful influence on the agriculture of that country."—*London Times.*

A NEW LUMINOUS POWDER.

It is reported that Lieutenant Diek, of the Russian naval service, has discovered a luminous substance which possesses the property of enduing with illuminating power any substance to which it is applied, or with which it is combined. The composition of the material (which is described as a powder) is kept secret; but it is apparently something of the nature of luminous paint. It is prepared in three colors—green, yellow, and violet; the latter being the most powerful. By putting a quantity of the powder into water contained in a glass vessel, the fluid becomes an illuminant. The inventor recently lectured on the preparation, at the Nicolai Engineering Academy at St. Petersburg, when he particularly referred to the advantages of his invention for mining operations, as there is no consumption of oxygen, and consequently no ignition or combustion. It is stated that the illuminating power of the powder lasts for eight hours, when the material must be changed. No particulars as to the luminous intensity or the cost of the composition are yet available.

THE SHAPIRA MANUSCRIPT OF DEUTERONOMY.

This remarkable manuscript, which has now been officially examined by Dr. Ginsburg on behalf of the British Museum authorities, may certainly be regarded as the archæological lion of the season. The alleged story of its discovery and the nature of its contents form another of those strange surprises which are by no means uncommon in the annals of Oriental archæology. The earthquake of 1837 was in all probability the means of bringing to light the now famous Moabite Stone, and a petty tribute-raising expedition of the Wali of Damascus some fifteen years ago rescued, according to Mr. Shapira's account, these important Moabite Scriptures from the cavern-tomb where they had been deposited. During the war which was carried on in the wadies and hills of the Modjib, and the basin of the Arnon, the Arabs had taken to the caves and holes in the rocks and carried on a guerilla warfare against the Turkish troops. We give a drawing of one of these wadies in the neighborhood of Aroar, a district where the manuscript is said to have been found. The limestone cliffs are full of caverns which had been used as tombs and temporary dwelling-places. One of the parties thus hiding discovered in a cave some bundles of linen black with age, and smelling strongly of bitumen. On opening them they were found to contain, not the much-desired golden treasure, but only narrow strips of leather covered with strange scratches (*nakash*). Some of the Arabs, disgusted with the apparent worthless nature of the find, threw away or burned their fragments; others, regarding the uncouth characters as talismanic signs, kept them, and good fortune coming to them in course of time was attributed to the possession of these magic scrolls. Mr. Shapira states that he first heard of the find in 1878, and after considerable trouble succeeded in obtaining thirty strips, some being duplicates, with more or less legible writing in the Moabite characters. The manuscript was first exhibited in the rooms of the Palestine Exploration Fund, and is now deposited in the British Museum. The strips are about forty-two inches long and three and a half inches wide, and contain on an average twelve lines of writing each. They are extremely black, and appear to be saturated with some oily or glutinous matter, and it is only by the application of spirits of wine that the text can be deciphered. The manuscript proves to consist of portions of two or more versions of the Book of Deuteronomy, presenting very considerable variations from the received Hebrew text. In the opening portion, Chapters I. and II. of the Authorized Version are combined; and in the Version of the Decalogue the two first Commandments are joined, and a new Commandment, "Thou shalt not hate thy brother in thy heart," introduced. The writing employed is almost exactly similar to the Moabite Stone, a strange use of the lapidary style in manuscript writing. In order that this may be seen, we have given some specimens of the various writings with which the text is being compared. The first (Fig. 2) is taken from the manuscript, and is the opening passage: "These are the words which Moses spoke according to the mouth of Jehovah," which may be compared with the writing of the first line of the Moabite Stone (ninth century B.C.) reading, "I am Mesha, son of Kemosh-Gad, King of Maob" (Fig. 4). There is a wide difference between these writings and the third example, taken from the Siloam Inscription, probably dating from the eighth century B.C., and a still greater from the fourth specimen, the oldest example, taken from a MS. of the sixth century A.D., in the Bible Society's Library at Odessa. In the opening passage of this manuscript the writer mentions the giants (*rephaim*) as former inhabitants of the land. Strange relics of these people are yet found in the cromlechs and dolmens scattered over the plains of Maob. The one of which we give an illustration was found in the Wady Zerka—the "ancient brook of Jabbok," the boundary of Gilead. The report which Dr. Ginsburg has made to Mr. Bond, the Principal Librarian of the British Museum, reveals the forged nature of the rolls. Both by external and internal evidence the MS. is condemned. It appears to have been written on a series of strips which had formed the lower margin of a disused synagogue roll. The internal evidence is still more curious, as it shows the remarkable fact that the text prepared by an amalgamation of portions of Leviticus and Deuteronomy was dictated to a scribe, who wrote it out in Moabite characters. The author of this new version not being versed in the Moabite paleography allowed several errors to pass which have revealed the nature of the fraud. The strips were then treated to a chemical bath to produce the antique appearance, and so prepared for sale. Since the days of Simonides no such barefaced fraud has been attempted on the *savants* of Europe.—*W. St. C. B. London Graphic.*

REDIER'S REVOLVING GLOBE.

All those who know that the axis of the earth is inclined to the ecliptic are shocked at the aspect of terrestrial globes, whose vertical axis, fixed on a standard, is far from giving an idea of what occurs in nature.

An approach has been made toward the real condition of things by inclining the axis on its support; and, owing to the skillful and scientific manner in which most of these globes are made, all their indications may be easily studied.

REDIER'S REVOLVING GLOBE.

The globe represented in Fig. 1 is much freer upon its axis than those hitherto made, and when, after having been left to itself, it comes to rest again, it revolves upon its pivots once in twenty-four hours, without revealing the motor that actuates it.

The clockwork mechanism (Fig. 2) is contained within the globe itself, and it is the movement of the mass, M, around the equator that, by changing the conditions of equilibrium, causes the globe to imperceptibly revolve.

It will be remarked that if the axis of the sphere were not inclined to the horizon, the movement of the mass, M, would not effect its rotation, and that it is precisely such incline-

1. A Single Fold of the Manuscript, Two Thirds of the Original Size.—2. One of the Strips of Leather on which the Manuscript is Written (AAA are the Joins).—3. The Wady, near Aroar, Palestine, Where it is Alleged the Manuscript was Found.—4. Various Specimens of Ancient Writing.—5. Ancient Dolmen (Relic of the "Giants" Mentioned in the Manuscript) in Jabbok Valley.

THE SHAPIRA MANUSCRIPT OF DEUTERONOMY.

tion that has been utilized to obtain a circular motion. This small object, which forms a clock, carries a hand that shows the hour of the place enameled on the equatorial circle. The two hemispheres are themselves of enamel and are only 85 millimeters in long diameter.

In appearance the hand remains stationary and the globe revolves under its point, but, in reality, it will be seen by consulting Fig. 2 that the clockwork mechanism causes the former to revolve once in 24 hours along with the mass with which it is connected. But, as this movement of the mass brings the whole into equilibrium, it is the globe that appears to the eye of the spectator to revolve.

As the equatorial circle of hours is movable, it is so fixed that noon comes upon the meridian of the city in which one lives, so that when the sun-hand marks noon it is superposed upon the said city. Thus we have a representation of what occurs in nature. To the right of the hand are the countries that are moving toward the setting sun—toward night; and to the left are those that are approaching midday. Beneath the enameled hour-figures, there are engraved small figures that serve to give the difference between the hour at all points of the globe and that at the city for which the equatorial circle has been adjusted. Thus, when it is 3 h. 30 m. at Paris we read 2 h. 15 m. on the meridian of St. Petersburg. Add 3 h. 30 m. to 2 h. 15 m. and we have 5 h. 45, the hour at St. Petersburg.

Much attention is being paid at present to the subject of the unification of the hour for the entire world, or at least for meridians that are pretty close to each other. If nations come to understanding on this point, the study of geography will become an absolute necessity, and the study of the terrestrial globe a household question, so it is well to familiarize ourselves with the subject now.—*La Nature.*

THE COLD WEATHER CURE.

SOCIETY suffers much from the scandal monger and the fault finder, but it is also a sufferer from those characterless persons who never speak ill of anything or anybody. However unpleasant it may be, it is decidedly right and proper that we should hear both sides of the question; and great harm may ensue from the incomplete information given by such sweet tempered people. A murderer is described by them as a man who always loved his mother; the thistle is a beautiful flower; a yellow dog is the type of affection; and March weather is the promise of spring. To such flatterers we are indebted for most of our popular information upon the subject of climate in its relation to health—especially the health of the consumptive—and so effectually have they done their work, that the untraveled citizen of New England comes to think of the West and the South as lands of the purest meteorological delight, hung with clouds of rose color, and warmed by a sun which never hides its face. But when the invalid says adieu to his friends and hies away to these lands, he finds that only the half—the pleasant half—has been told him, and, suffering from rain storms in the Adirondacks, or sand storms in Mexico, a winter chill in Texas, or a summer sunstroke in Dakota, he has cause to regret that the author of his guide book had too lovely a disposition to note the existence of these ills.

Occasionally a piece of unfavorable truth, originating from some observer who has no hobby to maintain, creeps into print. Here upon the Atlantic coast we are accustomed to think that we have the most changeable weather in the world, and that the West is a region of particularly equable temperature, in which the mercurial column is no longer mercurial, but almost stationary. We are therefore surprised when General Emory tells us of a change of temperature of sixty degrees between day and night on the Western plains. Mr. Ernest Ingersoll, in writing of Denver, that city of burning days and freezing nights, records a change of forty-eight degrees in a single hour. Mr. W. H. Bishop, describing San Francisco, repeats the current joke of the linen duster with the fur collar, with which it is necessary to equip one's self in order to be prepared for the freakish weather of that place. Mr. J. R. G. Hassard, in his letters from California, informs us that the belt of border between the fogs of the ocean and the dust storms of the desert is very narrow in that State.

The writer has himself observed a thermometric range of seventy-five degrees in twenty-four hours in that land of conglomerated climates; but this fluctuation was partly the result of a slight change of base in the observer. As for the barometer, the weather reports from St. Paul for April 29, 1883, show an amazing fall of more than two inches in the barometric column in the incredibly short time of five minutes, indicating an almost instantaneous atmospheric rarefaction equivalent to that which would accompany an increase of two thousand feet in the elevation of the town. As the surface of weak lungs is particularly sensitive to sudden changes of weather, the New Englander may well think twice before he prefers these regions to his own home of steady habits and not very unsteady temperature. Whatever faults New England may have, it is comparatively free from such paroxysmal phenomena as blizzards, cyclones, cloud bursts, earthquakes, sand storms, and the atmospheric upheavals and ground and lofty tumbling of the thermometer noted above.

The partisan nature of our information upon these subjects is due not only to the charitable disposition of our informers, and to the enthusiasm of the returned tourist, who, however much he may have grumbled on the spot, always reviews his travels with rapture, but also to other and grosser causes. The newspaper correspondent in Florida finds a receipted board bill under his plate, and a new vision is given unto him. A distinguished author, with one lung, is presented with a cottage in Colorado, and straightway he feels renewed vigor, and publishes the fact in glowing terms. Here is a clipping from a Minnesota newspaper: "Dr. C——n, of Philadelphia, the most famous lung doctor in America, and the standard authority on all pulmonary complaints . . . proposed to build a grand sanitarium in Philadelphia, to lay a line of pipes to it, and, by the aid of the Falls of St. Anthony, pump the bright, pure air into the patient's wards, holding that thereby he could accomplish results that would astonish the world."

The secret spring of the above outburst, which may be the cause of misleading some unfortunates, is found in the fact that its brilliant author was a member of the National Convention of Physicians, which assembled in St. Paul in the early part of June, 1882. They were welcomed there with a hospitality right royal, such as it would be difficult for an Eastern city to imagine. Free board at the hotels and free tickets over the railways were theirs. Dinners, receptions, and garden parties were given them without stint. Added to these attractions, the weather was as perfect as glorious June could make it, and the doctors would have been less than human if they had confined their appreciation to the plain yea and nay of sober language. The raptures of the invited guests are very pleasant and readable, but they are not instructive. On the other hand, a series of descriptions of our different health resorts, written by people who have paid their own board bills, and who have no real estate to sell, might not enrich the publisher, but they would make excellent reading for our sick friends, to whom an ounce of truth is worth whole pounds of the current deception.

Minnesota is more or less celebrated as a sanitarium for pulmonary complaints. Thither goes the invalid, with an abnormal fondness for cold weather, brought about by a surfeit of the other extreme of temperature. All extremes, however, work injury to the physical system, especially when it is weakened by disease. It is not less unhealthy to have one's nose frozen with cold in Montana than to have it blistered with heat in Arizona. He who leaves the languor of the tropics for the bracing air of the far North reasons that cold is preservative and antiseptic, and that warmth means decay; and that it is as unwise to expose a wounded lung to a high temperature as it would be to place a wounded leg under similar conditions. Very true, but after a long and dreary winter, with the thermometer at zero or thereabouts, the idea vividly strikes him that death is a state of coldness, while warmth is symbolical of life; and that it behooves him to be very careful lest the faint spark of vital warmth be frozen out of his feeble frame.

As far as sanitary statistics can be said to prove anything, they demonstrate that there is not more consumption in the north latitudes of civilization than in the south. The people of the South are naturally more attentive to cleanliness and ventilation than those of the North, where the bath room has the air of a refrigerator, and storm windows are put up in October. The Southerner also breathes a larger share of the open air than his northern neighbor, but still, in physique he is more slender, and in constitution less hardy. Ergo, the northern atmosphere, of which, in its out door purity, we get but scanty draughts in winter, must have superior life-giving properties. Indeed, the beneficial effects of a crisp, frosty morning need no demonstration to either sick or well, and if we could find a climate made up of crisp, frosty mornings, where it was always champagne-like autumn, with the ground always dry under foot, and the sky always clear overhead, it might be a very good place to set up a sanitarium for the consumptive.

Minnesota lies in the latitude of northern New York and Canada. St. Paul and Minneapolis, which attract most of the travel, are situated very near the parallel which forms the north boundary of New York. They have consequently a very cold climate in winter, and there are long periods of low temperature, during which the sick man cannot do otherwise than hug the stove, although he may realize with every breath he draws that the coal gas of Minnesota is not less poisonous than the similar product at home. When it comes to a choice between slow poison and rapid freezing, few are so heroic as to choose the latter. Impure air is the penalty of the invalid's life in the far North. As the ship-wrecked sailor dies of thirst upon the boundless waters of the sea, so he starves for oxygen, although immersed in a deeper and broader ocean of pure air. But he is cut off from this generous supply by a house wall which is made up of several layers of plaster, brick, wood, and paper, and by windows which are hermetically sealed. With the best of intentions and the firmest resolves he cannot avoid this evil spirit of foul air, unless he be a gentleman of leisure, with sufficient means to build his own home and regulate his own domestic affairs. If engaged in business, he will be sure to have some associates who will resent any intrusion of fresh, cold air. The hotels are double-doored and stifling with the accumulated fumes of the winter, and of course the landlady of his boarding house cannot be expected to understand the economy which would intentionally admit a current of cold air, and then put on more fuel to warm it. They tell of a man in St. Paul who sought to overcome this difficulty by running a tube from an aperture in the window to his seat by the fireside, and breathing through it; but the mental strain and physical effort of the process were too much for his reduced strength, and he died. Others have been known to pry open a window in their chamber for ventilation, and to go to bed for bodily warmth; but such a method of sequestration from society cannot be recommended for general use.

Perhaps it would seem that the best way to get the fresh air is to simply go out and take it, but in a country of extreme cold there are some objections to so radical a measure as this. The colder the weather without, the hotter are the fires within doors—a very unwise method of compensation—and it not unfrequently happens that the inner temperature may be at seventy-five degrees above zero, while the external air is twenty-five degrees below that point. To step out of doors at that time is to voluntarily submit ourselves to an instantaneous change of one hundred degrees, which cannot but be injurious to the physical organism. If the natural variations of temperature were half as violent as those which we inflict upon ourselves, we would complain most bitterly. And what shall the invalid do out of doors? Though he wrap ever so warmly he cannot sit upon the veranda with either pleasure or profit. Sleigh-riding is an equally chilly entertainment for the feeble. Active exercise is the only safe resource left him. Let us suppose that he has sufficient strength for a daily walk of ten miles. That will consume but three hours out of the twenty-four. But ten miles is a very liberal allowance, and is more than most well persons care to walk. People do not realize that they are sick as long as they are capable of such exertion. One hour's vigorous exercise is more likely to be the limit of the invalid's endurance. This must be done with a rush to avoid chill. Where the pedestrian should loiter he is obliged to stride. When exhausted, he dares not sit down by the wayside to recover his breath. The excessively cold air, rapidly pumped in and out of his overtaxed lungs, produces a sickening effect. Even persons in the fullness of health, but of delicate organization, are sometimes prostrated with headache and nausea as a result of a mile's walk in a hyperborean temperature. Extremes are *not* healthy.

Out of door occupations in winter, for those who needs must work, are not plentiful. It takes strength to be a lumberman, skill to be a farmer, technical knowledge for the surveyor, and endurance for all. The policemen and hack drivers are hardy and full-blooded fellows, with an enviable color in their cheeks, but only such men can breast the storm and live. The street car driver wears a buffalo-skin overcoat, a fur cap, and a hood over his nose, and seating himself upon the little stove on the front platform, takes the fresh air with impunity; but then we cannot all drive horse-cars.

Many stories are related of the Northwest which should be salted when swallowed. The cold weather of that region is spoken of as a new, delightful, and innocuous kind of frigidity, but still the physicists find that the absence of heat produces pretty nearly the same effects all the world over. People are fond of saying that they have suffered more from cold in Charleston than in Winnipeg. Undoubtedly they have, if they were so indiscreet as to wear pajamas in the former place while they wrap themselves in fur in Manitoba. The extreme cold of the Northwest is said to be dry, and therefore harmless. Certainly, all great cold is dry; even in Vermont it does not rain when the thermometer is at zero. It is also said to be a steady cold, but that is not true. Its only claim to steadiness arises from the fact that it is always cold, although in a degree which is not less variable there than elsewhere. Thus in a Minnesota winter the ordinary and expected range of temperature, through which the mercury jumps with great rapidity at times, may be put at fifty degrees, running from about ten degrees below zero to forty above. On the Atlantic coast the corresponding range is about equal in extent, though different in position, reaching from ten degrees above zero to, say, sixty degrees above. This estimate does not include the occasional extremes of temperature, which, in either country, would extend the range each way a distance of ten or twenty degrees.

Who has not heard the story of the lumbermen in the pine woods of Minnesota, working in their shirt sleeves with the thermometer at forty degrees below zero? It is a true story. It could not be otherwise, as it is considered highly unprofessional, in every clime, for a woodman to attempt to swing an axe with his overcoat on. But there is no limit to the number of shirts which he is allowed to wear, and some of these lumbermen are wrapped in as many thicknesses of clothing as those bulbous-bottomed Dutchmen that Washington Irving tells us about. Moreover, being made of that remarkably heavy stuff, Mackinac flannel, each thickness is a wardrobe in itself.

The writer takes the liberty of disbelieving the experiences related, often by invalids themselves, of enjoying a temperature of forty degrees below zero. But, even if enjoyable, it cannot be healthy. Freezing to death is said to be a pleasant process, but it can scarcely be called a healthy one. Minus forty degrees would freeze the bloodless face of a sick man, and a frozen nozzle or cheek, however delightful for the time, is a source of torment for one season at least. History tells of martyrs who, roasting on a heap of coals, have asked if they were reclining on a bed of roses; but, if we except the loving woman who has made a mistake in the selection of a husband, history tells of no martyrs more devoted than those determined pioneers who, having chosen a new country for their future home, heroically resolved to be satisfied with their choice, come what may.

While Minnesota is usually considered a synonym for cold weather and the play-ground of the young blizzard, we do the State a great injustice when we assume that minus forty degrees is a customary or even frequent occurrence in its settled portions, and that the mercurial column is in the habit of retiring into its bulb for winter quarters. Even in the coldest winters the thermometer generally stands on the sunny side of zero. In some respects the temperature, which is always, or nearly always, below the freezing point, offers great inducements over the weather which, in our mid-latitudes, oscillates in winter, with pendulum-like regularity, from one side to the other of that critical degree of cold, freezing one day and thawing the next, giving pneumonia with its ice and fever with its mud. Minnesota is almost free from the horror of winter rains. An umbrella carried at that time of year is a monstrosity there. Nor are there any green Christmases to foretoken fat graveyards. In this stability of a constantly frozen climate there are undoubted advantages for certain temperaments and constitutions which a warmer country cannot offer. Whether they are sufficient to induce the consumptive to immigrate thither, is for himself to decide. If in his weakness he shrinks from the thought of cold weather, he will gain no health by immolating himself on a snow-bank; but if he has strength and desire for such heroic treatment, he will find it an excellent corrective for the miasm with which his system may have become soaked in the tropics. Could he discover a land with the thermometer always just below the freezing point, it might be worth a trial; but he might as well look for a perpetual June, or a country where it is always afternoon. Every advantage in this world is balanced by some disadvantage, and in seeking to avoid the Scylla of winter slush and mud, he is sure to run upon a Charybdis of polar temperature.

The spring of the year, to which the consumptive looks forward so longingly, is but a beautiful siren, luring him on his destruction. The winter, with its confinement, weakens him; the spring, with its lassitude, aided by its damps and chills and changes, kills him. No statistics are needed to convince the thoughtful observer that this is the most fatal season for pulmonary complaints. In the lands of the north it is especially so, as the thawing-out process is there prolonged to correspond with the great thickness of frozen soil. For weeks and months the earth is in a cold sweat, as the healthy warmth of the atmosphere is withdrawn to melt the ice under ground. The result is that worst of all conditions for the lungs, a surface of cold mud. One secret of the great success of wheat raising in the Northwest is said to be the unusual depth of frozen ground, which, thawing gradually through the growing season, keeps the roots of the grain constantly supplied with moisture. But the consumptive differs from the wheat in his needs; the great desideratum in his case is a dry soil beneath his feet.

As a chain is no stronger than its weakest link, so is a climate, for permanent residence, only as healthy as its most unhealthy season. It is cold comfort to live through eleven months of the year only to die in the twelfth. The old lady was wiser than she knew when she said that she had always noticed that if she lived through the month of March she lived through the whole year. The healthfulness of Minnesota, judged by the spring mortality from diseases of the throat and lungs, does not appear to deserve the praise that it has received. St. Paul has an annual death rate of about twenty-five to a thousand inhabitants. In March, 1883, forty per cent. of the total deaths in that city were from diseases of the respiratory system. Thirty-one per cent. or nearly one-third of the deaths during the entire spring of 1882 were from similar causes. Our Eastern cities do not show worse records than these for the same months.

True, less than half of the above fatal cases are reported under the head of "consumption," but the only safe way to judge of the healthfulness of a climate with respect to that disease is to sum up the total deaths from complaints of the organs of respiration. It is proverbial that the victim of consumption is extremely reluctant to admit the fact, but indulges in the self-deception of locating his ailment in his throat, or liver, or elsewhere. Consumption, like death itself, is spoken of with bated breath, but under another name it is shorn of half its terrors. Why an ailing lung should be considered more discreditable or deplorable than

a defective liver or larynx it is not ours to know, but it is nevertheless true. A very clear case of consumption once came under my observation, but a sister of the dead denied the disease with indignation, because, as she naively said, "consumption isn't in our family;" she could scarcely have displayed more heat if she had been asked if her grandfather was hanged. Such examples as these show the inevitable unreliability of the statistics upon this subject, as reported by the census. When we consider farther that no two cases of consumption are exactly the same in nature and position; that no two physicians will agree in their definition of the word; and that, in a region which has a reputation to maintain, as all pretended sanitariums have, the doctor would not be a loyal citizen if he did not take advantage of every possible doubt, we need not be surprised if, even in the medical records, some cases of consumption come to us disguised under the names of hemorrhage, tuberculosis, inflammation of the lungs, inflammation of the bronchi, etc.

Comparative death rates, like mean temperatures, relative and absolute humidities, and many other phrases seemingly scientifically exact, may mean much or little, according to the manner in which they are used.

Dr. Alfred L. Loomis, of New York, who sends consumptive patients to the Adirondacks, reports progress, in *The Medical Record*, of a selected list of twenty cases of these. Of this number ten, or one-half, were cured, and, up to the date of the report, only two had died. That is a very favorable showing at first glance, but on reading between the lines we learn that all of the fortunate ten had been afflicted with "catarrhal phthisis," while all cases of "tubercular phthisis" grew constantly worse and are probably dead before this time. The above is a beautiful illustration of the manner in which the words of a medical report can be arranged to befog and convince the reader, ever willing to be befogged and convinced. At any rate, it behooves the invalid, suffering from old-fashioned consumption of the lungs, to find out whether his phthisis is "catarrhal" or "tubercular" before muffling himself in the clouds of the Adirondacks.

Taking a more cheerful view, now, of the climate of Minnesota, we find that, for summer and autumn, the percentage of deaths from lung disease in St. Paul is very much less—probably not more than half—of the corresponding rate in spring. Indeed, in the mortuary list of that city for July, 1883, for which I have to thank the courtesy of Dr. C. A. Wheaton, health officer, consumption makes no appearance at all as a factor, although acute lung and bronchial complaints contribute a liberal quota to the dead. This variation, with the season of the year, of the rate of mortality from pulmonary causes is noticeable in all countries, although perhaps in a less marked degree. When a storm passes over the orchard it shakes off all the fruit that is ready or nearly ready to leave the bough, and for a time thereafter the windfalls are few.

The traveler in Minnesota will receive meteorological reports from two persons, the boomer and croaker. The former will assure him that, with possible exceptions, the climate is strictly Italian; the latter declares that not only do the aforementioned exceptions prove the rule, but they are the rule itself; and he is never weary of rehearsing his account of the Fourth of July meeting which was broken up by a snow storm of the pitiless blizzard in winter, chasing the [illegible] to his death, and howling over his body like a thousand wolves in concert. Truly, it is difficult to draw the plain truth from him who has a theory to fortify. Mr. Charles Nordhoff, in his anxiety to prove that California is a good place for consumptives, makes the extraordinary statement that even the fogs of that State are dry and warm. As a wonderland, California, which now has a health resort named Nordhoff, always did take the lead; but still a dry fog is more than we could reasonably expect from it. Mr. Sidney Lanier, in his work on Florida, published a few years ago, said positively that consumption is a curable disease, and referred in proof to his own successful struggle with that trouble. Mr. Lanier is now in his grave: cause, consumption. Mr. Marc Cook spoke in similar terms of himself and the Adirondack region, but no sooner had he heralded his cure to the world than, with the inconsistency of the consumptive, he died. Mr. Cook, however, is said to have made a pretty plum of money by the publication of his book upon that subject, which is more than is expected from the unvarnished literature of these pages.

The writer was once thrown into intimate relations with one of the early pioneers of Minnesota, who sounded unceasingly the praises of his adopted State, from a pulmonary point of view. Each emaciated newcomer was cheered by him with the assurance that he would weigh two hundred pounds before the year was gone. This assurance, however, lost much of its cheer when it was subsequently learned that this gentleman's wife and daughter, after a life of a quarter of a century in Minnesota, had grown ill with consumption and had gone to their old home in Massachusetts to die; and that his son, anticipating similar trouble, was an annual visitor to Florida, where he was in the custom of spending the worst months of the year. Yet it was evident that this old resident firmly believed that consumption was hardly a possibility in Minnesota. He had learned to believe it in his youth, and it takes more than the trifling occurrence of a few deaths in the family to disabuse an old man's mind of the errors of his early faith.

Since this State is now so old as to have home-born citizens who have reached the age of liability to consumption, it has been obliged to surrender the boast—common to new countries—that no native has ever died of that disease. But this claim is not lost; it has been picked up by the younger communities of Colorado and Dakota, whose oldest white natives are not beyond the juvenile ailments of mumps and measles. Minnesota, however, still maintains, with other sanitariums, that the presence of consumption in her mortuary lists is principally due to the importation of invalids suffering with that complaint when they arrive. Not so. The immigration to the Northwest, which is largely peopled with leather-lunged Scandinavians, is especially free from the consumptive element, owing to the fact that a tendency toward that disease is usually linked with a horror for cold. Those who are so idiosyncratic or so heroic as to try the cold weather cure usually return to warmer climes as death draws near. Outsiders who go to Minnesota to die are, to all appearances, by no means so numerous as the residents who, pining in their last days for green trees, open windows, and soft airs, go elsewhere for that sad purpose, and thus subtract their names from the death roll of the State. During a year's residence there the writer noted the deaths from consumption of citizens who had expatriated themselves, for their healths' sake, in Chicago, New York, Boston, Florida, Colorado, California, and other places, thus betraying a very reprehensible and unpatriotic want of confidence in their own climate.

The reader who visits a public library, seeking information upon the sanitary properties of Minnesota, will probably find there a book called, upon its cover, "Minnesota as a Home for Invalids," and upon its title page, "Minnesota as a Home for Consumptives." It is by Brewer Mattocks, M. D., formerly president of the Board of Health of St. Paul. In it the author appears to make the most strenuous and conscientious efforts to tell the truth, and at times goes out of the way to advise the consumptive not to come to Minnesota. Then he proceeds to reel off such seductive promises, such false and alluring statements of prominent physicians, and such captivating and deceptive statistics, that the sick man goes there out of pure inability to stay away. After picturing the invalid as laying plans in the long hours of his convalescence, by which he acquires wealth after his restoration to vigor, he makes the very strong assertion that "most of our large business and professional men in St. Paul sought our climate for health." This in itself is enough to start the invalid to St. Paul. Arriving there, and seeing that the leading citizens, as a class, betray no signs of former debility, he comes at last to question the truth of the above statement. Every one, however, as in duty bound, assures him of its reliability. Still incredulous, he begs the names of a few of these restorations. The first is given quickly and fluently, and almost invariably refers to the same prominent citizen, who, the victim of slow consumption, is not dead yet. The second name comes less readily. The third requires a still greater amount of thought. The fourth is told with hesitation, if at all. At all events the fingers of one hand are enough to hold the entire list. This is an excellent game to play in an idle hour. This dwindling of the majority teaches us how little are people in the habit of thinking before they speak, and what a very small amount of truth there is current among us. It also reminds us of the story of the boy's thousand cats in the back yard, which, on rigid investigation, were brought down to "our cat and another one."

I beg the pardon of the good people of Minnesota for writing thus flippantly, but they should really cultivate more moderate habits of speech when dwelling upon the advantages of their State, and should muzzle their literary doctors lest they publish other wild advertisements for the deception of the sick. The plain truth about the attractions of Minnesota, whose merchants supply an empire and whose mills grind grain for the world, will be sufficient to draw thither a population as fast as it can be economically disposed of. St. Paul is already receiving more people than it can house, and it will profit the city but little to make it a rendezvous for the disappointed sick. Better for the future of the State that it should be stocked with strong men, even though the doctors should find their occupation gone.

In presuming to discuss so broad a subject as the climate of a country, the writer does not pretend to describe it for all time. He would simply record the impressions derived from a residence of a year and a half under its influence. Stated in summary, the autumn of 1881 in Minnesota was as truly a rainy season as ever was experienced in Oregon or the tropics, but this was certainly an exceptional season. The winter of 1881–82 was clear, charming, and unexpectedly mild. There were many days when it was difficult to understand how the weather could be at once so dry and so warm in a snow-covered country. This was said by the old residents to be the regular Minnesota weather, although there were rumors afloat that it really belonged to the column of exceptions. The spring of 1882 was of the most atrocious and cut throat character. March lingered into the lap of May, and buffalo-skin coats were worn until June. This season was said by the citizens to be exceptional, but the cynical non-residents strongly suspected it to belong to the regular order. The following summer was sufficiently pleasant, with cool nights and invigorating days, not unlike the mountain weather of the East. There are, however, wide variations of temperature there at this season to be provided for; the range for July, 1883, was from fifty-two degrees to an even hundred in the shade. The fall of 1882 was not remarkable, furnishing cause for neither raptures nor complaints. It was highly praised by the residents, but the traveler found it lacking in some of the glories of an autumn on the Atlantic sea-board. Then came the terrible winter of 1882–83, which I fear may be accepted as typical Minnesota weather. A large part of the time the thermometer was at zero or below. When not too cold to snow, the sun was dimmed and the sky was darkened with storm. Comfort out of doors there was none. The country was swept by blasts, and the streets of the town were like refrigerators. All who could leave the State hastened to seek more congenial climes, and hence the ending at this point of the present weather chronicle.

After all of this discussion we come again to the question, Which is the most favorable latitude for the treatment of consumption? Shall the invalid seek the South, with its miasmatic damps and ramshackle hotels, and let the debilitating influences of the tropics undermine his system and the annual cold snap kill him? Shall he go to the North, with its disadvantages such as we have described? Shall he stay at home in the mid-region of inconstant temperature, which, like the angel of Laodicea, is neither hot nor cold, and where pneumonia carries him off before consumption has a fair chance at him? Or shall he go to that town in the far West, of which we read the story that its citizens, assembled in theatrical audience, left the hall in indignation during the representation of *Camille*, claiming that their climate was so healthy that it was impossible for any one to die of consumption there, even upon the mimic stage.

In this dilemma, the wise invalid, if such there be, will consult principally his comfort and convenience in laying his plans for residence. Should he go south for warm weather, or north for cold, he will go forewarned that dangers and discomforts await him in every zone. Especially will he dismiss from his mind the fallacy that all changes of climate are necessarily salutary. Excessive rarefaction of air or excessive dryness cannot do good to a respiratory apparatus which nature has adapted to the ordinary state of the atmosphere. Man, like all other living organisms, slowly but surely accommodates himself to the physical conditions by which he is surrounded, and to transplant him suddenly to a widely different home is an act of violence to nature, only to be remedied by another period of acclimation.

While Minnesota, as a sanitarium for consumptives, may not be worth the journey thither, it is equally possible that it is not worth while for its residents to go elsewhere in search of health. At any rate this land of hospitality, enterprise, and prosperity is a very pleasant place to spend the summer, as can be proved by thousands of people from the whole length of the Mississippi Valley, who go there every year to shake off their cares and their malaria. There they find magnificent hotels on beautiful lakes, where the men leave their families while off hunting the duck and deer, or making more distant excursions into the land of the buffalo. To tell the whole truth, however, which has been the aim of this paper throughout, the mosquitoes of Minnesota are simply fiendish, and the arms of the belle at the hop and the legs of the hunter in his camp are alike mottled with their bites.

FRANK D. Y. CARPENTER.

HARD WORK IN SPORT.

Some of the boys who were delighted last week by the picture given at the Gentlemen's Driving Park of life on the plains ought to make a note of the fact that along with the fun of the cowboys there was a great amount of hard work. Even the tame steers and buffaloes are not worth much more than it costs in labor to lasso them, and the energy expended in their work by cowboys would make the fortune of any Eastern boy who should stick to his trade here and buy his beef ready dressed.—*Public Ledger.*

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